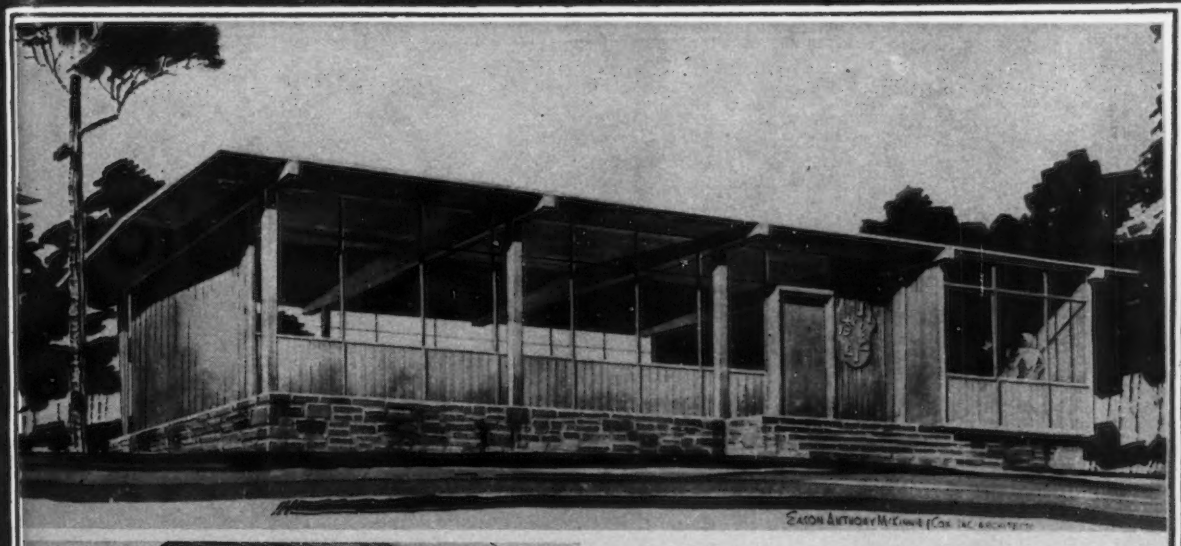
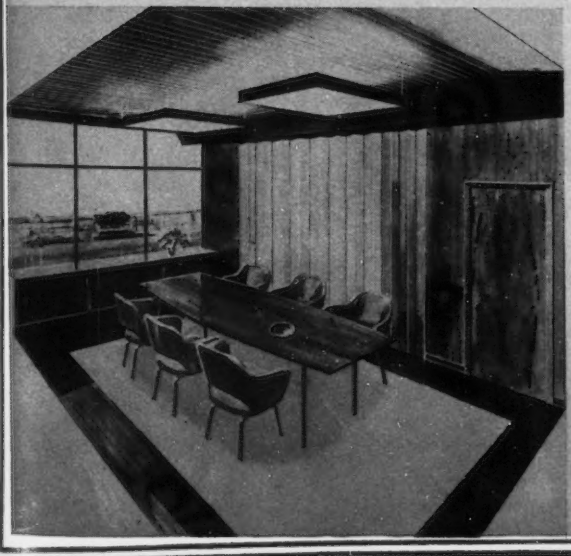
PARTICLE BOARD FOR FURNITURE CORE—p. 91

Forest Products Journal

Vol. VII, No. 3 March, 1957





Needed: This New FPRS Home Office ...and $60,000 to Finance It

See page 7-a

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BUSS No. 44

THE IDEAL PLANER for ROUGH MILL CONVEYORIZED SET-UPS!

BUSS No. 44 — 4 roll, single surface planer. Capacities: 26" through 50". Feeds up to 105' P.M.

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IMPORTANT FPRS DATES

May 2–3: Northern California Section Meeting, Berkeley, Calif.

May 9–10: Carolinas–Chesapeake Section Meeting, Clemson, S. C.

May 9–10: Midwest Section Meeting, Peoria, Ill.

May 13–14: Pacific Northwest Section Meeting, Roseburg, Ore.

May 31: Florida–Georgia–Alabama Section Meeting, Talladega, Ala.

June 24–28: Eleventh National Meeting, Hotel Statler, Buffalo, N. Y.

August: Upper Mississippi Valley Section Meeting, International Falls, Minn.

Oct. 21–22: Mid-South Section Meeting, Crossett, Ark.

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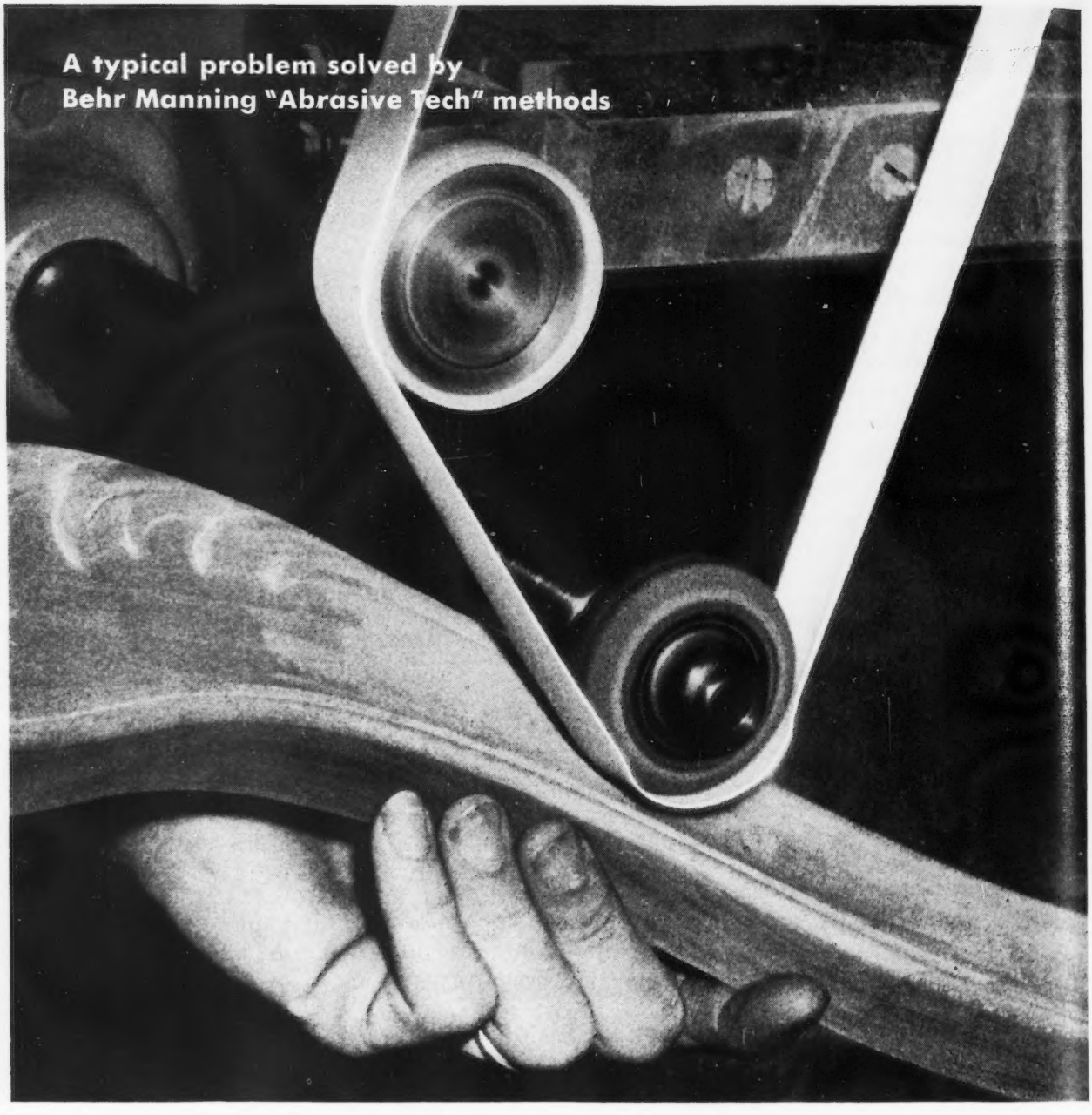

Finishing time cut 50% on these cherry bed posts. One Behr-Manning abrasive belt sanded 170 posts in 3 hours. Formerly it took 6 hours and 15 abrasive discs to do the job. Machine is an Albright Master Spool Sander.

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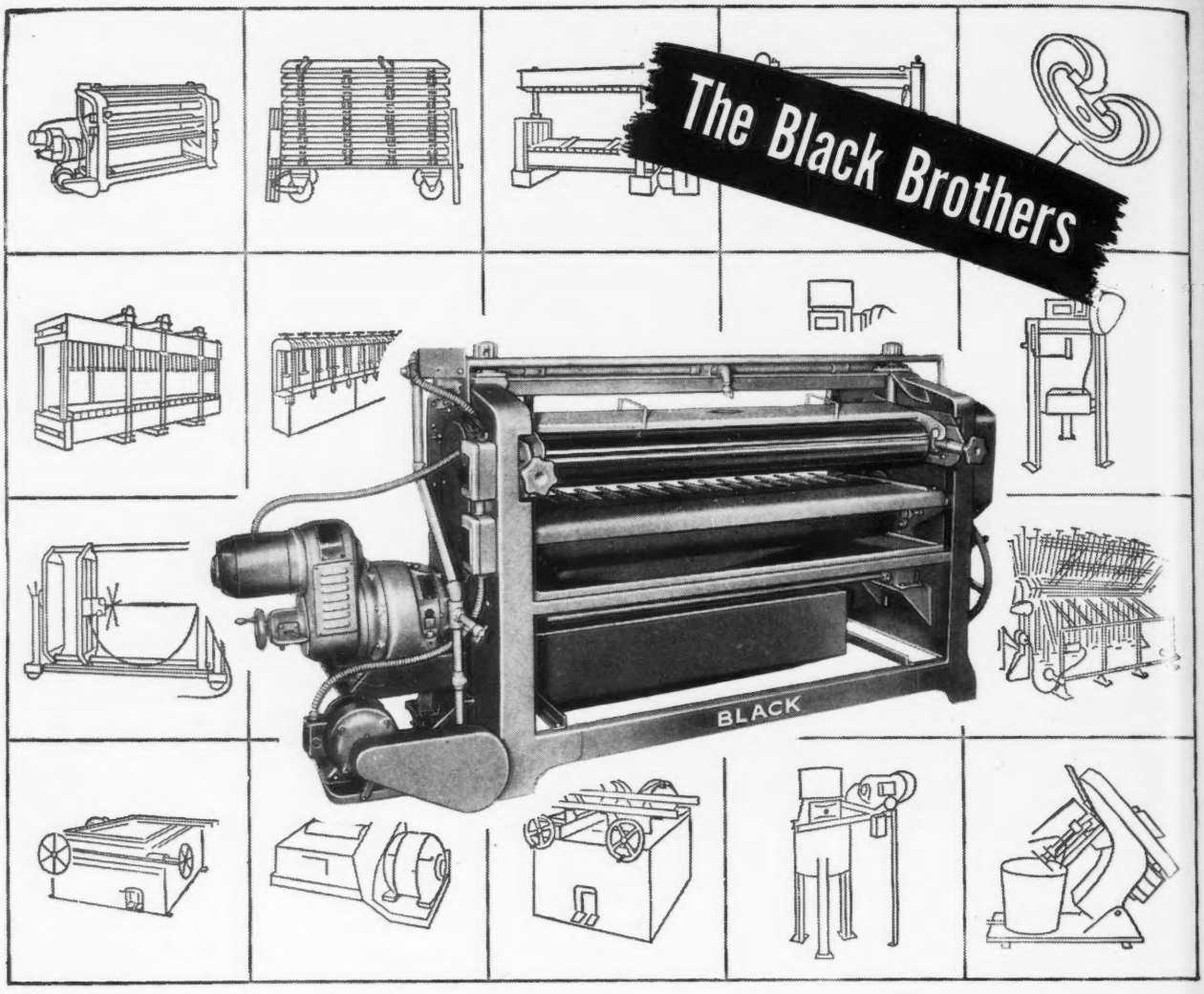

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"If It Is Gluing Equipment - We Have It"

THE BLACK BROTHERS CO., INC.

MENDOTA, ILLINOIS, U. S. A.

FPRS NEWS-DIGEST

Volume VII MARCH, 1957 Number 3

Drive Launched for Executive Office Building Fund

Nation-Wide Team Seeking Goal of $60,000 Prior to National Meeting in Buffalo

An accelerated fund-raising drive for the proposed FPRS Executive Office Building was kicked off this month by a nation-wide team of key men in the Society. They are seeking to raise a total of $60,000 in cash and pledges by June 24, opening day of the Eleventh National Meeting in Buffalo.

Headed by Raymond H. Berry, Southwest Regional Board Member, the Fund-Raising Committee consists of Executive Board Members, Section officers, and other leaders in Society affairs.

Plans Outlined

First step in the drive was the mailing to all members of a special brochure outlining plans for the drive, the present need, estimated costs, and description of the proposed building. This initial appeal to members was made in keeping with the Society's philosophy of developing "from the ground up".

The next approach will be to individual companies that benefit directly or indirectly from work of the Society. These firms will be contacted on a state-by-state basis for contributions in amounts of $100, $500, and $1,000.

Final Results at Buffalo

Between now and the National Meeting in Buffalo, members of the national fund-raising "team" will appear at all FPRS Section meetings to report on progress toward the goal and to enlist further financial support. Final results of the drive will be announced at the Buffalo meeting.

Assuming that the $60,000 goal is achieved, present plans call for proceeding with construction so that the building may be dedicated during the Twelfth National Meeting in Madison, June 22–26, 1958.

Progress Since 1947

Founded in 1947 by a nucleus of 14 men, FPRS membership currently is approaching 3,500 and the staff consists of nine full and part-time employees.

In the past ten years, the Society was privileged to lease office space at the U. S. Forest Products Laboratory. The Laboratory's research program and staff have expanded in recent years, however, necessitating increased office space. Recognizing this, the FPRS Executive Board in 1953 began looking at available buildings in Madison which might be purchased. However, the Board concluded that the best and lasting solution would be for the Society to erect its own office building representative of the industry.

In 1954 the Society purchased a building lot which today is valued in excess of $10,000. Located near the Forest Products Laboratory, the lot is completely paid for and many improvements have already been installed.

The Board also commissioned W. J. Eason, vice-president of Nickey Bros., Memphis, Tenn., president of a leading architectural firm and member of the FPRS Executive Board, to design the future office building. Special permission was obtained from the city of Madison to construct an all-wood commercial building and final architectural plans were accepted by the Board in late 1954.

An initial materials and fund-raising program was inaugurated in early 1955, with an appeal to companies in the wood industry to contribute the required lumber and other wood-base materials. Generous response to this resulted in virtually filling all materials requirements.

Because of the Forest Products Laboratory's increasing need for the offices being occupied by the Society, the headquarters of FPRS were moved in February 1957 to the present location at 911 Regent Street, Madison.

There are several reasons why the Executive Board deems it advisable to proceed with construction of a new building at this time.

1. The Society is growing rapidly, with promise of a great future.

(Continued on page 8–A)

CONTRIBUTION OR PLEDGE CARD

Name _____

Address _____

I hereby (contribute) (pledge) my support to the proposed FPRS Executive Office Building to be erected as early as possible, consistent with conservative business practice, in Madison, Wisconsin.

(Check here for Contribution and enclose check or money order) ☐ $_____

(Check here for Pledge. We will invoice you for the amount of pledge during calendar year 1957) ☐ $_____

Signed _____

It is estimated that membership will reach between 7,500 and 10,000 in the next decade.

2. An office building owned outright would give the Society a form of reserve if needed in the future. The Society's income is closely related to the nation's economy. In the event of a national economic setback, ownership of real property would offer FPRS a measure of security to tide it over.

3. FPRS is presently leasing office space at a cost of $3,000 per year—money which could be spent to better advantage on a building of its own.

4. Although present office space is adequate, the staff could profitably utilize as much as 50 per cent more working space.

5. Finally, a permanent office building for FPRS would be a perpetual and sound investment for the industry. Annually, thousands of wood industry executives and technologists from throughout the world visit the U. S. Forest Products Laboratory in Madison. They would also be attracted to the services of and membership in FPRS.

Estimated Costs

The $60,000 goal was set by the Executive Board in order to own the building debt-free and provide for at least one year's operating expenses. Cost for constructing the building is estimated up to $60,000, including some $15,000 worth of donated materials — lumber, siding, beams, arches, decking, paneling, etc.

In addition to the building lot, the Society has a $13,000 cash surplus, a separate contributed building fund of $3,000, and $1,000 in pledges. Thus, on a cash basis alone, more than 20 per cent of the goal has been subscribed already.

Plans for the building call for two finished office levels of 1,500 square feet each, air conditioning, parking lot, drives and landscaping. Throughout, it will emphasize wood as a symbol of strength, beauty, and versatility in construction. The building will be surrounded by specimen trees symbolic of the nation's commercial forests.

Contributions Tax-Deductible

The Forest Products Research Society is a registered non-profit corporation. Thus contributions to the building fund (as well as membership dues) are deductible expenses in estimating federal and state income taxes.

Announce Candidates for National Offices

Nominating committees have selected candidates for FPRS national and regional offices, to be elected by mail ballot. Results will be announced at the Eleventh National Meeting June 23–28 in Buffalo, N. Y.

Dr. Frank H. Kaufert, current President-Elect, will automatically become President in June, succeeding Ralph H. Bescher, Koppers Co., Pittsburgh, Pa., Mr. Bescher will remain on the Executive Board as Past President.

President-Elect Kaufert is Director, School of Forestry, University of Minnesota, St. Paul, Minn. He was associated with duPont Chemical Co. and the U. S. Forest Products Laboratory before joining the Minnesota faculty, is a former member of the Council of the Society of American Foresters.

F. H. KAUFERT

W. J. EASON

Candidates for other offices are:

President-Elect: W. Jeter Eason, Vice-President, Nickey Brothers, Inc., Memphis, Tenn. Currently serving as FPRS Vice-President, Eason served as South–Central Regional Board Member, 1953–56; General Chairman, 1953 National Meeting; and as Chairman of the Deep South Section. He is also president of the architectural firm of Eason, Anthony, McKinnie and Cox, Memphis, designers of the proposed FPRS Executive Office Building.

Vice-President (One to be elected): Elwood S. Harrar, Dean, School of Forestry, Duke University, Durham, N. C.; or John D. Ritchie, Director, Allied Products, Douglas Fir Plywood Association, Tacoma, Wash. Dr. Harrar served as Southeast Regional Board Member, 1953–56; was Chairman pro tem in organization of Carolinas–Chesapeake Section and later served as Section Trustee and Secretary-Treasurer. Mr. Ritchie is concluding a three-year term as Northwest Regional Board Member, has been with the Douglas Fir Plywood Association for 20 years.

E. S. HARRAR

J. D. RITCHIE

Northeast Regional Board Member, 3 Years: Donald K. Saunders, President, Saunders Brothers, Westbrook, Maine. Currently Northeast Section Chairman, Saunders has served as Section Vice-Chairman and is Vice-Chairman in charge of Budget and Finance of the 1957 National Meeting.

D. K. SAUNDERS

T. S. VEAZEY, Jr.

Northwest Regional Board Member, 3 Years: T. S. Veazey, Jr., Assistant Research Engineer, Anaconda Copper Mining Co., Butte, Mont. Veazey, who has served as Secretary-Treasurer and Chairman of the Inland Empire Section, has been associated with Anaconda since 1936.

1958 National Nominating Committee (4 to be elected): A. L. Mottet, Long-Bell Division, International Paper Co., Longview, Wash.; E. E. Dargan, Dargan Lumber Manufacturing Co., Conway, S. C.; C. F. VanEpps, Stromberg–Carlson Co., Rochester, N. Y.; N. V. Poletika, Timber Engineering Co., Washington, D. C.; R. C. Rietz, U. S. Forest Products Lab., Madison, Wis.; J. C. Rowney, Pacific Woodworking Machinery Co., Berkeley, Calif.; R. W. Hess, Mengel Co., Laurel, Miss.; and R. W. Wellwood, University of British Columbia, Vancouver, B. C.

Important Notice

The Constitution of FPRS provides that "Voting shall not be restricted to the names submitted. 25 voting members may file with the Executive Secretary, within 30 days after notification of the action of the nominating committees, the name of an eligible candidate for any elective office for which they are entitled to vote. The name of such candidate shall be placed on the ballot. Further, any voting member may vote for any eligible member of his own choice for any elective office by inserting the member's name on the ballot."

Chairmen Report Technical Session Themes

Latest Research Progress in 12 Fields to Feature Buffalo Meeting Program

Chairmen of 7 of the 12 technical sessions scheduled for the National Meeting at Buffalo have described the themes for their sessions, emphasizing the latest research in various phases of forest products development. They report that authors will cite problems facing their particular fields and the approaches to their solution through research.

Pointing out the industrial and individual progress resulting from past FPRS national meetings, the chairmen are enthusiastic that the authors and panel members again will contribute important research knowledge to the more than 700 persons expected to attend. Speakers will come from the U. S., Canada and overseas, and their occupational backgrounds range from basic research through wood utilization, emphasizing the broad geographic and industry-wide scope of the material to be presented.

With abstracts or papers already in from more than half the authors, the themes of the remaining sessions will be formulated shortly and are expected to be announced next month, along with a preview of most of the technical papers and panels.

Glues and Gluing

Richard F. Blomquist, Session Chairman. Tuesday, June 25, 9:00–11:30 a.m.

Higher labor, production, and distribution costs make more efficient wood utilization imperative. Numerous possibilities for achieving greater efficiency are apparent and the key to all of these is the glue joint. Wider use of modern glues certainly will have a positive effect upon wood utilization in the future. This includes edge gluing and end gluing of lumber, bigger and better laminated timbers, new plywood products, and composite products of wood, plywood, paper, plastics, hardboard, particle board, and metal.

R. F. BLOMQUIST

A. A. MARRA

Development of composite wood flooring or siding through combination of wood species, and higher strength species are examples of new developments. Their importance in achieving greater forest products utilization, and the key role played by modern glue techniques, will be emphasized throughout the presentations at this session.

Logging

Fred C. Simmons, Session Chairman. Wednesday, June 26, 9:30 a.m.–12 noon.

Efficient utilization of the nation's wood supply must begin on its logging operations. If the various wood-using industries are to continue to obtain the raw material they need, at a price they can afford, the loggers are the ones who must supply it.

But many problems plague the logger in his attempts to meet these demands. Labor is becoming more costly and more difficult to find; stands are sparser and more remote, often in swamps or on rough mountainsides; and costs for equipment and supplies are rising steadily.

To offset these factors, tremendous change has been taking place during the past few years. The power chain saw and the four-wheel-drive rubber-tired skidding tractor are just two of the new developments making it possible to do a better job of logging with fewer men in today's scattered stands.

Also, logging techniques are changing, grading specifications are improved, integrated logging is being widely adopted, and techniques are being developed for the separate harvesting of logging residues.

Some of the recent developments along these lines and probable future developments in more efficient operations will be discussed at this session. Emphasis will be placed on the importance of combating new and different safety hazards.

Lumber Manufacturing

Milton H. Mater, Session Chairman. Thursday, June 27, 9:00–11:30 a.m.

Dimensional quality control is practiced in all competing industries, but until recently was neglected by the forest products industry. It was not uncommon for smaller mills to saw lumber ¼-inch or more larger than necessary, and then waste the lumber in the planer and burner.

But today, when it is so necessary to get the most lumber out of every

F. C. SIMMONS

M. H. MATER

log, dimensional quality control takes on added significance.

At this session, the methods used to make sure of length, width, and thickness will be outlined and explained. It is intended that the papers on quality control in the sawmill, and the panel discussion will act as a guide and inspiration to the lumber industry to manufacture more and better lumber, and to conserve timber resources by getting more lumber out of each log.

Wood Drying

Stephen B. Preston, Session Chairman. Thursday, June 27, 9:00–11:30 a.m.

The purpose of kiln drying is threefold: dry wood uniformly to the desired moisture content, do this within the shortest possible time, and do it at minimum cost.

This session will point up the importance of these basic objectives with practical papers on how to accomplish all three. Because of the meeting location, papers have been selected primarily with manufacturers in the Eastern U. S. in mind.

A report to be presented on mechanical properties of red oak related to drying is one of the few studies of its kind, and should contribute materially to basic knowledge of wood drying. Of particular interest to Southern manufacturers will be the paper on kiln drying of hardwood cross ties in preparation for preservative treatment by a revolutionary time-saving technique.

A paper on the analysis of factors affecting the cost of hardwood drying should be of interest to custom

(Continued on page 16-A)

S. B. PRESTON

F. H. THOMAS

Advance Program Outline

Sunday, June 23

1:00–5:00 p.m. Registration, Mezzanine Floor, Hotel Statler

3:00–5:00 p.m. Executive Board Meeting; Northeast Section Board Meeting

5:30–8:00 p.m. National Committee Meetings: 5:30–7:00 p.m. Employment; 6:00–8:00 p.m. Publications; 6:00–8:00 p.m. Membership; 7:00–8:00 p.m. Industry–Education Division.

7:00–9:00 p.m. Reception, Maple Leaf Room, Hotel Statler. Get-together period sponsored by Host Section (Northeast) and Cooperating Section (Eastern Canadian).

Monday, June 24

9:00 a.m.–6:00 p.m. Registration

9:00 a.m.–9:00 p.m. Suppliers Exhibit: Exhibit Hall on Mezzanine Floor adjacent to meeting rooms. Door prizes on display.

8:00–10:30 a.m. FPRS Employment Service

8:30 a.m.–12:30 p.m. Problem Clinic and Division Meetings: 8:30–10:30 a.m. Logging, Chemical Utilization, Machining, Quality Control, Glues and Gluing, Drying, Packaging; 10:30 a.m.–12:30 p.m. Lumber Manufacture, Preservation, Finishing, Veneer and Plywood, Composition Board, Marketing, Industry–Education

10:00–11:30 a.m. Ladies Kaffee Klatsch, Buffalo Room

1:15–5:15 p.m. General Opening Session: Welcoming Remarks by Mayor of Buffalo, Northeast Section Chairman D. K. Saunders, Eastern Canadian Section Chairman E. A. Thompson; Synopsis of Program by General Chairman Charles R. Lockard; Address by President Ralph H. Bescher; Northeast Section Student Awards; Address by Dr. Lincoln Thiesmeyer, President, Pulp and Paper Institute of Canada; Vance Publishing Co. "Wood" Awards; Hitchcock Publishing Co. "Award of Merit" Presentations; National Business Meeting

6:30–8:30 p.m. Past Presidents' Dinner

7:00–9:00 p.m. Section Officers Meeting

Tuesday, June 25

8:30 a.m.–5:00 p.m. Registration

9:00 a.m.–6:00 p.m. Suppliers Exhibit. Door prizes on display

9:00 a.m.–11:00 a.m. Technical Sessions I and II: Glues and Gluing, Machining

12:30 p.m.–2:30 p.m. Official Luncheon: Address by Fred C. Foy, President, Koppers Co., Inc.

2:45–4:45 p.m. Technical Sessions III and IV: Veneer and Plywood, Finishing.

2:30–5:30 p.m. Employment Service

2:30–4:30 p.m. Ladies Tea and Surprise, Empire State Room

5:00–9:00 p.m. Children's Zoo Picnic

7:00–9:00 p.m. Official Banquet: Dinner, Door Prizes, Entertainment

Wednesday, June 26

8:30 a.m.–12:30 p.m. Registration

9:00 a.m.–6:00 p.m. Suppliers Exhibit

9:00–11:30 a.m. Employment Service

9:30 a.m.–12 noon. Technical Sessions V, VI and VII: Logging, Composition Board, Preservation

1:15–5:00 p.m. Plant Tours: Carborundum Co., Upson Co., Kittinger Co., Wurlitzer Co.

1:00–5:00 p.m. Ladies' and Children's Tour: Niagara Falls, Ontario

5:00–6:00 p.m. Refreshment Hour: Men—Hotel Niagara, Niagara Falls, N. Y.; Ladies—Hotel Sheraton–Brock, Niagara Falls, Ont.

6:30–9:00 p.m. Paul Bunyan Smorgasbord and Tour: Smorgasbord at Brock Monument Park, Night Tour of Niagara Falls

Thursday, June 27

8:30 a.m.–12:30 p.m. Registration

9:00 a.m.–6:00 p.m. Suppliers Exhibit

9:00–11:30 a.m. Technical Sessions VIII, IX and X: Lignin Utilization, Wood Drying, Lumber Manufacture

12:00–1:30 p.m. Section Officers' Luncheon; Division Chairmen's Luncheon; Organization Luncheons

2:00–4:30 p.m. Technical Sessions XI and XII: Chemical Utilization and Quality Control

2:00–4:00 p.m. Ladies' Tour: General Mills plant tour conducted by Betty Crocker

4:00–5:00 p.m. Northeast Section Business Meeting

Friday, June 28

1. Optional visits to wood industry plants within 200-mile radius of Buffalo that will hold open house.

2. Special invitation visit to new Wood Products Laboratory of State University of New York College of Forestry, Syracuse.

3. Historical tours of Buffalo area.

39 Suppliers Sign As Paul Bunyan Sponsors

Four additional firms supplying materials and services to the wood industry have signed up as hosts for the Paul Bunyan Smorgasbord and Tour, entertainment highlight of the Eleventh National Meeting June 23–28 in Buffalo. They are: Barrett Division of Allied Chemical & Dye Corp., Kennametal, Inc., Koppers Co., and Reichhold Chemicals, Inc.

Meeting registrants and their families will be guests of the sponsoring firms at a smorgasbord supper at Brocke Monument Park in Ontario on Wednesday, June 26, and an evening tour of Niagara Falls.

Firms interested in sponsoring this event, traditionally a feature attraction of FPRS meetings, are invited to write A. G. Battaglia at National Adhesives, 270 Madison Ave., New York, N. Y.

Sponsors signing up to date include:

American Cyanamid Co., New York, N. Y.
American Manufacturing Co., Tacoma, Wash.
Bahnson Co., Winston–Salem, N. C.
Barrett Division, Allied Chemical & Dye Corp., New York, N. Y.
Bauer Bros. Co., Springfield, Ohio.
Black Brothers Co., Inc., Mendota, Ill.
Borden Co., New York, N. Y.
Carborundum Co., Niagara Falls, N.
Clark Equipment Co., Battle Creek, Mich.
Cleworth Publishing Co., Industrial Woodworking, Cos Cob, Conn.
Peter Cooper Corp., Gowanda, N. Y.
Delta Power Tool Div., Rockwell Mfg. Co., Pittsburgh, Pa.
Durez Plastics Div., Hooker Electrochemical Co., North Tonawanda, N. Y.
Hitchcock Publishing Co., Wood Working Digest, Wheaton, Ill.
Kennametal, Inc., Latrobe, Pa.
Koppers Co., Pittsburgh, Pa.
The Lilly Co., High Point, N. C.
Masonite Corp., Chicago, Ill.
Mattison–Greenlee Service Corp., Rockford, Ill.
Merritt–Solem Div., Solem Machine Co., Lockport, N. Y.
Moore Dry Kiln Co., Jacksonville, Fla.
National Casein Co., Riverton, N. J.
Nelsonite Chemical Products, Inc., Grand Rapids, Mich.
Nicholson Mfg. Co., Auburn, Wash.
Pacific Lumber Co., Scotia, Calif.
Perkins Glue Co., Lansdale, Pa.
Preston Woodworking Machinery Co., Ltd., Preston, Ontario
Protection Products Mfg. Co., Kalamazoo, Mich.
Reichhold Chemicals, Inc., White Plains, N. Y
Simonds Saw and Steel Co., Fitchburg, Mass.
Soderhamn Machine Mfg. Co., Talladega, Ala.
Southern Screw Co., Statesville, N. C.
Standard Dry Kiln Co., Indianapolis, Ind.
Synvar Corp., Wilmington, Del.
Timber Engineering Co., Washington, D. C.
Wilco Machine Works, Inc., Memphis, Tenn.
Williams Patent Crusher and Pulverizer Co., St. Louis, Mo.
S. A. Woods Machine Co., Boston, Mass.
Yates–American Machine Co., Beloit, Wis.

Variety of Plant Tours Planned at Buffalo

June 26 Set as Plant Tour Day; Betty Crocker Will Be Hostess to Ladies

A choice of four scheduled wood industry plant tours—from the largest wood mill in the country devoted to the manufacture of musical instruments to the exclusive maker of Williamsburg restoration furniture pieces—awaits FPRS members and guests at the Society's Buffalo meeting.

Wednesday, June 26, has been designated as Plant Tour Day. In addition, Chairman George Fahlstrom has scheduled visits to wood industry plants within a 200-mile radius of Buffalo on Friday, June 28, including the new wood products laboratory at the State University of New York College of Forestry at Syracuse.

Fahlstrom did not overlook the ladies when making tour arrangements. A special visit to Betty Crocker at the General Mills plant in Buffalo will be made on Thursday, June 27.

Tour Highlights

The Carborundum Co., Niagara Falls, 22 miles northwest of Buffalo. The tour will include a trip through the Coated Abrasives Divisions, following the flow of materials from receiving, making of coated abrasives in giant machines that contain up to 10 miles of coated abrasives in one run, then on to the jumbo rolls in the stock room, into the finishing departments where upwards of 30,000 different kinds, sizes and shapes of coated abrasives are processed, through packaging and shipping. The tour will conclude by viewing sanding machines in action, using abrasive belts in a manner simulating their use in industrial plants. Visitors also may see the largest coated abrasive making machine in the world, and the world's largest abrasive belt surface grinder in action.

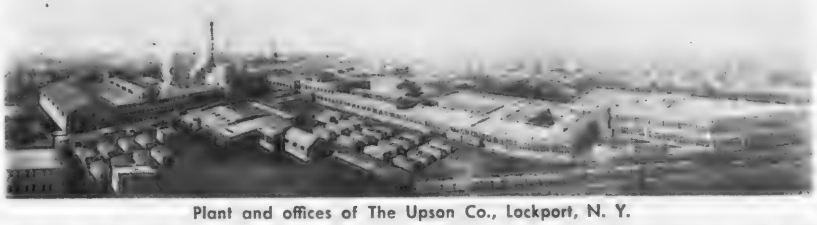
General Mills, Inc., Buffalo. Betty Crocker will describe the processes used in making cake mixes and frostings, Bisquick, Softasilk Cake Flour, Wheaties and other General Mills cereals. The ladies will tour the Cereal Plant, from which they can see the large grain elevator, storage facilities and flour mill.

Kittinger Company, Inc., Buffalo. One of the oldest makers of fine traditional furniture in the U. S., Kittinger is famed for the skilled hand-craftsmanship of its workers. The company holds exclusive appointment as maker of Williamsburg Restoration Furniture Reproductions. The visitors will see all steps of the furniture production process, from dry kilns to final finish.

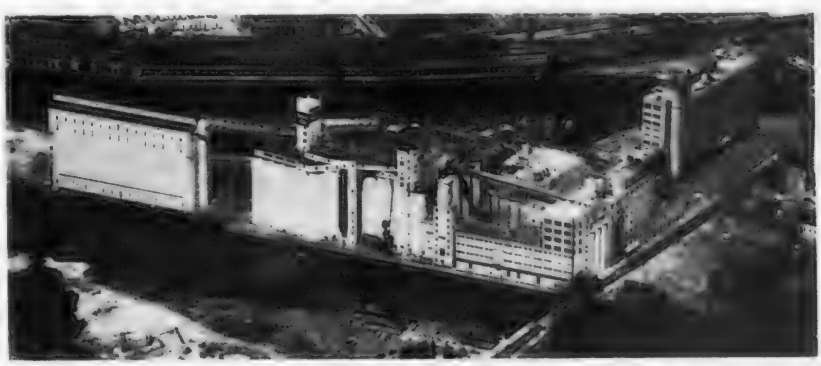
State University of New York College of Forestry at Syracuse, 150 miles east of Buffalo on the State Thruway. Arrangements will be made for those wishing to visit the new $3.75 million Hugh P. Baker Memorial Wood Products Laboratory at Syracuse. The laboratory, with 96,000 square feet of floor space, houses the Departments of Forest Chemistry, Wood Technology and Wood Utilization. Special equipment includes a complete veneer and plywood laboratory; electronic gluing equipment; sawmill specially designed and equipped to study lumber manufacturing problems; complete wood preservation plant, with five cylinders; wood finishing laboratory; woodworking laboratory with standard machines and some specially designed for high speeds; variety of humidity and temperature control rooms for long time observation, as well as working laboratories under controlled conditions. Visitors also may view the five different type dry kilns, several special laboratories and special instruments for studying the physical and chemical properties of wood and cellulose.

The Upson Company, Lockport, 20 miles northeast of Buffalo. Visitors will view the manufacture of Upson's many products, including laminated panels, crackproof walls, primed siding, wood fiber panels and their product applications, "Tuco" puzzles, and Upson Board. The plant has a complete paper machine and pulp making process. Its products serve such diverse uses as: packaging, shipping, toy manufacturing, television cabinet backs, furniture, book binders, liners, dividers, dis-

Coated Abrasives Division, The Carborundum Co., Niagara Falls, N. Y.



Plant and offices of The Upson Co., Lockport, N. Y.



General Mills, Inc., Buffalo, N. Y.

Main entrance of Rudolph Wurlitzer plant.

play and advertising signs, porch ceilings, sheathing, walls, and siding.

Rudolph Wurlitzer Company, North Tonawanda, 12 miles north of Buffalo. The plant contains the largest mill in the U. S. devoted to the manufacture of musical instrument cases, accounting for 175,000 square feet of the total plant space of more than 750,000 square feet. Visitors may view the complete Wurlitzer production process. Lumber is unloaded directly from box cars to kiln loads. Six electrically controlled kilns handle all core and dimension stock. As stock is moved to the production area, it is handled on a straight line production set in a single floor building 1,200 feet in length. All core stock is edge-glued with electric gluing machines. Panels are layed up next and then moved to the final machine section where all pieces are given final special processing. Sub-assemblies are prepared to specified model and finish. The units and their components move to the finishing section, and finally to the final assembly point where mechanical units are installed.

Transferring load of lumber into dry kiln at Wurlitzer plant.

Employment Committee Plans Placement Service

A placement service to assist employers seeking men, and persons interested in positions in the wood industry, will be conducted by the FPRS Employment Committee at the Society's National Meeting in Buffalo.

Committee members will be on hand at the Hotel Statler for four days during the meeting; Monday, June 24, 8:00–10:30 a.m.; Tuesday, June 25, 2:30–5:30 p.m.; Wednesday, June 26, 9:00–11:30 a.m.; and Thursday, June 27, 2:00–4:00 p.m. Private interviews may be arranged by appointment. To assist in processing applications, it is suggested that firms with definite employment needs and individuals looking for jobs obtain application forms from the FPRS national office in Madison, Wis., prior to the meeting.

FPRS Employment Committee members assisting with the program are: Chairman Newell A. Norton, School of Forestry, Pennsylvania State University, University Park, Pa.; Richard W. Petterson, St. Paul and Tacoma Lumber Co., Tacoma, Wash.; Harvey H. Smith, U. S. Forest and Range Experiment Station, Berkeley, Calif.; Eldon A. Behr, Chapman Chemical Co., Memphis, Tenn.; E. R. Martell, Department of Forestry and Conservation, Purdue University, Lafayette, Ind.; and Roy M. Carter, School of Forestry, North Carolina State College, Raleigh, N. C.

In addition to the special placement service at the meeting, the Employment Committee is also conducting a summer "on-the-job" training program for college students. Encouraged by the success of the program in 1956, the Committee has again surveyed colleges and firms, with more than 30 schools and 40 companies already responding. Information regarding the program is available from members of the Committee, the FPRS national office or from FPRS faculty representatives at colleges and universities.

Battaglia and Rosse Join National Meeting Committee

A. G. Battaglia and David Rosse, National Adhesives, 270 Madison Avenue, New York, have been named to the Paul Bunyan Committee of the Eleventh National Meeting by General Chairman Charles R. Lockard. Joseph Coufal resigned as Paul Bunyan Chairman recently after accepting a new business position in Virginia.

Other National Meeting Committee personnel not previously reported are: E. A. Thompson, Chairman, Cooperating Section (Eastern Canadian); Donald Pierce and J. Allan Hauter, finance committee; W. F. Pfeil, information and hospitality; F. K. Henrich, rooms; L. S. Jacobs, meals; M. E. Schleicher, signs and decorations; Henry S. Davis, hotel liaison committee; Willard Fichtel, publicity in Jamestown area; Floyd E. Carlson, television and radio advisor; Mrs. Darwin Ellis, ladies events; and H. L. Bennett and C. A. Babcock, suppliers exhibits.

ADVANCE REGISTRATION

ELEVENTH ANNUAL MEETING—FOREST PRODUCTS RESEARCH SOCIETY
BUFFALO, NEW YORK—JUNE 24-28, 1957

Return to: Buffalo Convention and Tourist Bureau, 155 Franklin St., Buffalo 2, N. Y.

Name _____
Last First Middle

Address _____

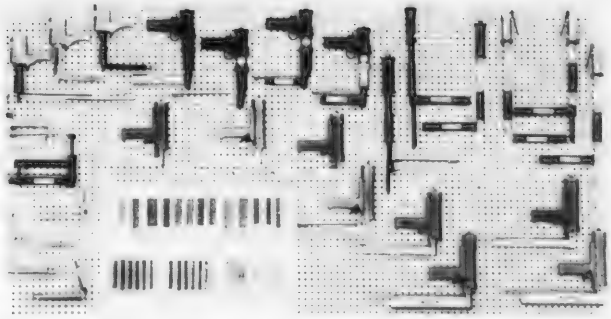
Company or Organization _____

REGISTRATION (including abstracts) Enter Amount Below

☐ FPRS Member	$ 8.00	☐ FPRS Official Luncheon		$ 3.00	$_____
☐ Non-Member	$12.00	☐ FPRS Banquet and Party	single	$ 8.00	$_____
☐ Ladies Program	$ 5.00		couple	$14.50	$_____

☐ Paul Bunyan Niagara Falls Tour and Smorgasbord—No Charge

Total Enclosed $_____



MODEL of this continuous particle board extrusion machine will be displayed by Adamson United Co. Complete line of air staplers (right) will be shown by Power-Line Sales, Inc.

Suppliers Report Buffalo Exhibit Features

More Than Third of Booth Space Already Reserved for Meeting

Nine of the firms reserving space for the Wood Industry and Suppliers Exhibit have announced the products and displays to be featured and the personnel who will be on hand at their exhibits, according to Russell C. Deckert, Exhibit Chairman. Several other exhibitors have indicated that their displays are in the planning stage and details will be announced shortly.

The Exhibit will be held in conjunction with the Society's Eleventh National Meeting June 23–28 at the Hotel Statler in Buffalo, N. Y. The exhibits will be located on the mezzanine floor, adjacent to the meeting rooms.

Deckert reports that two more firms have reserved space within the past month, bringing the number of exhibitors to 26: Miller Hofft, Inc., Richmond, Va., and Fastener Corp., Chicago, Ill.

Space still is available, Deckert added, and companies desiring to display products and services should contact him at State University College of Forestry, Syracuse 10, N. Y.

The firms announcing their exhibit plans are:

Mater Machine Works, Inc., Corvallis, Ore.—Engineering drawings, photographs, reprints of articles describing mill modernizations and the study of blueprints, surveys, and other material of interest to operators of both large and small mills, concerned with increasing mill productivity and automating operations. Personnel: Milton Mater, president.

National Starch Products, Inc., New York, N. Y.—Multisection Kwik-Klamp process press, Woodlok, Granite Board, and their various applications. Personnel: James Dillon, vice president; A. G. Battaglia, manager; John Meany, Eastern sales supervisor; James Elf, Midwest sales supervisor; and P. H. McCormick, field engineer; all of the Structural Products Division.

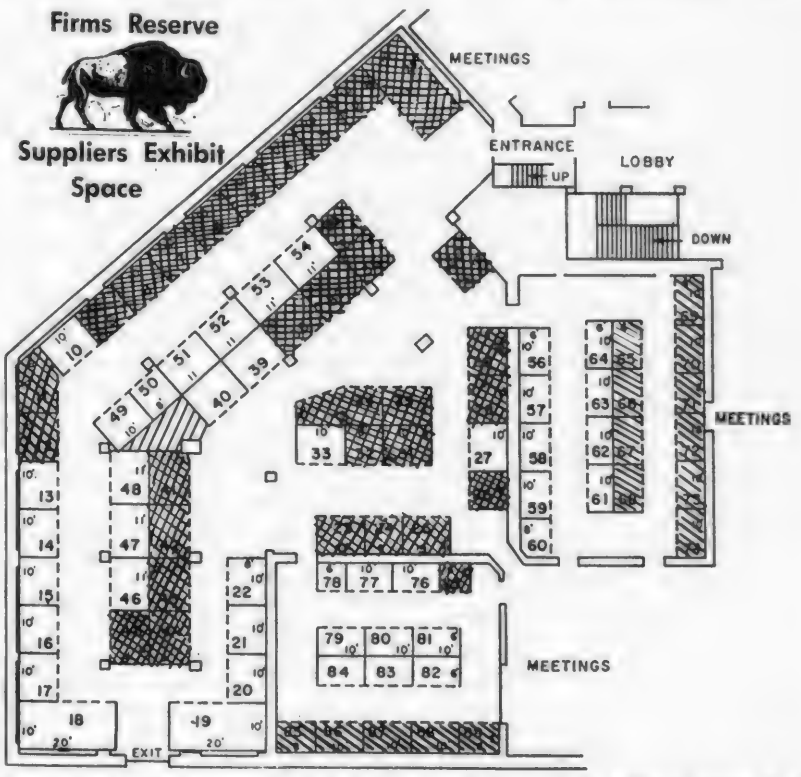
Power–Line Sales, Inc., Detroit, Mich.—Complete line of air staplers, including the new series of light weight air staplers (PL series) especially designed for cabinet work, assembling drawers, case backs on furniture, sash and door work, etc. Personnel: Harold Dickinson, Rochester, N. Y.; Frank Laidlow, Emerson, N. J.; and Bruce McIntyre, Memphis, Tenn.

Deluxe Saw and Tool Co., Louisville, Ky.—Complete line of carbide-tipped cutting tools and sawblades, including rip saws, cut-off saws, trim saws, thin rim saws, true helix spiral cutters, shaper knives, and various form cutting tools. Personnel: A. G. Feldmann, vice president, engineering; Nat C. Campbell, district manager, Midwest area; and Cal W. Tittsler, district manager, Southern Atlantic region.

Adamson United Co., Akron, O.—Continuous chipboard extrusion machine—model of the Lanewood machine and process. Personnel: George S. Andrus, senior engineer, Adamson United; representatives of the Lane Co., Altavista, Va.

Timber Engineering Co., Washington, D. C.—Display panels showing roof test, pilot plant particle board production, bending jig, chemical drying, ladder test, end and edge jointing conference. Personnel: R. C. Cranch, assistant to director of research; and other staff members.

Peter Cooper Corps., Gowanda, N. Y.—Typical applications of ani-



BOOTH SPACE is being reserved rapidly for the Wood Industry and Suppliers Exhibit to be held during the FPRS Eleventh National Meeting June 23–28. Cross-hatched areas indicate space already reserved.

mal, liquid animal and resin adhesives in varied furniture and woodworking operations; samples and complete technical information on Cooper woodworking adhesives. Personnel: Robert C. Gill, technical service representative, Gowanda, N. Y.; George W. Grace, Western sales manager, Chicago, Ill.; G. P. Nonweiler, sales representative, Indianapolis, Ind.; Warner W. Haslett, sales representative, Richmond, Va.; and H. F. Zahn, sales representative, Buffalo, N. Y.

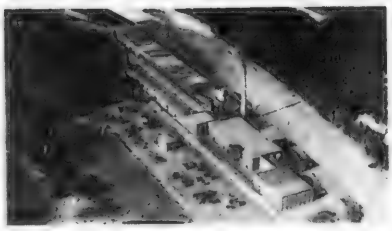
National Casein Co. of New Jersey, Riverton, N. J.—Complete display of firm's products, with various applications demonstrated. Personnel: Elmer Bergay and Richard Thomas, technical department; Obie Derr and Robert T. Cousins, salesmen, Riverton plant; George Tasker, technical department; A. H. Marten and Robert Archambeault, salesmen, Chicago plant.

Senco Products, Inc., Cincinnati, O.—Display and demonstration of staplers and tackers, featuring Model E and Model BNFX lines, using low carbon staples. A 16 mm. film will be shown in a separate suite, showing staples being used in various woodworking fields under actual production conditions. Personnel: William Tillinghast, vice president and sales manager, Cincinnati; Leo Bernstein, sales, Pittsburgh; Irving Goodlerner and Charles Landy, sales, Eastern New York; Ben Iaia, sales, Rochester, N. Y.; Jack Armacost, sales manager, Chicago, Ill.; Art Rickling, sales manager, Detroit, Mich.; and John Price, sales manager, Cleveland, O.

Firms reserving space to date include:

Adamson United Co., Akron, O.
Bahnson Co., Winston Salem, N. C.
Bauer Brothers Co., Springfield, O.
Deluxe Saw and Tool Co., Louisville, Ky.
Fastener Corp., Chicago, Ill.
General Electric Co., Carboloy Department, Detroit, Mich.

Applications of National Casein adhesives will be demonstrated.



Adhesive products of Peter Cooper Corps. plant at Gowanda, N. Y. (above), will be exhibited.

Heil Co., Milwaukee, Wis.
Industron Corp., Newton Highlands, Mass.
International Harvester, Chicago, Ill.
Kennametal, Inc., Latrobe, Pa.
Masonite Corp., Chicago, Ill.
Mater Engineering, Corvallis, Ore.
Mattison–Greenlee, Rockford, Ill.
Miller Hofft, Inc., Richmond, Va.
Moore Dry Kiln Co., Jacksonville, Fla.
National Casein of New Jersey, Riverton, N. J.
National Starch Products, Inc., New York, N. Y.
Onsrud Machine Works, Chicago, Ill.
Orr & Sembower, Inc., Reading, Pa.
Pacific Mutual Door Co., Tacoma, Wash.
Perkins Glue Co., Lansdale, Pa.
Peter Cooper Corps., Gowanda, N. Y.
Power Line Sales, Inc., Detroit, Mich.
Price and Rutzebeck, Hayward, Calif.
Senco Products, Inc., Cincinnati, O.
Soderhamn Machine Manufacturing Co., Talladega, Ala.
Standard Dry Kiln Co., Inc., Indianapolis, Ind.
Timber Engineering Co., Washington, D. C.
Wel–Dri Co., Memphis, Tenn.
Yates–American Machine Co., Beloit, Wis.

Staplers and tackers will be shown by Senco Products, Inc.

Wood Working Digest Awards of Merit to be Given at National Meeting

Following a precedent established at Grand Rapids in 1954 and Seattle in 1955, the Hitchcock Publishing Co., publishers of Wood Working Digest, will again present their "Awards of Merit" at the FPRS National Meeting in Buffalo. The awards will be presented by Vincent C. Hogren, Executive Vice-President, during the General Opening Session on Monday, June 24.

The awards will be given to organizations who, in the opinion of an independent judging committee, have made notable contributions to wood utilization or marketing during the preceding calendar year. They are made to "publicly commend the work of those who are promoting a better understanding of wood utilization—to call attention to the need for public information and education—and to publicize ways and means being used to prove the advantages of wood." The awards are based on entries by organizations desiring to participate in the competition.

A separate award may be made for each of the following divisions:

A. Lumber, dimension stock, veneer and plywood.

B. Products made from wood waste.

C. Finished wood products such as furniture, flooring, toys, etc.

D. Wood components — girders, boat timbers, laminated arches, furniture parts, etc.

E. Materials that make possible an expanded use of wood—adhesives, finishes, chemicals, abrasives, etc.

F. Machinery for: improving quality of wood products, developing more efficient production—providing opportunity for new manufacturing methods, new products, more efficient utilization of wood.

G. Schools, colleges, universities, and institutes.

Some idea of the standards to be used in judging entries may be obtained from the following questions asked of participants. Did the product, process, or procedure that you emphasized during 1956 do any of the following: Promote the utilization of wood or wood products? Develop new uses for wood or wood waste? Improve the quality of your wood products? Represent a short cut to production or quality control? Encourage research? Increase Sales? Any firm, association or school is eligible to participate in the competition.

Program Announced for Midwest Section Meeting May 9 and 10 in Peoria

The complete program for the Spring Meeting of the Midwest Section has been announced by Chairman J. J. Allegretti. The meeting will be held May 9 and 10 at the Pere Marquette Hotel, Peoria, Ill.

Featured on the program will be a tour of the U. S. Dept. of Agriculture's Northern Utilization Research Branch laboratory at Peoria. Two plant tours are also scheduled during the meeting.

Registration will be held the morning of May 9, with the tour of the Northern Utilization Research Branch laboratory scheduled that afternoon. Dr. W. D. Maclay, chief, will explain the laboratory's work and objectives. New Considerations in the Utilization of Forage Crops and Agricultural Residues of Interest to the Wood Utilization Industry will be discussed by Dr. H. J. Dutton, Head, Forage and Agricultural Residues Section. Dr. T. F. Clark, Head, Pulping and Mechanical Processing Unit, will speak on Pulp and Paper Making Materials from Agricultural Residues.

A Paul Bunyan Hour in the Pere Marquette lounge will conclude the opening day's program.

The morning program on May 10 will open with the Section Business Meeting, to be followed by a full technical session. Speakers and their topics will be: R. D. Behm, Executive Secretary, Hardwood Plywood Institute, Prefinishing of Panel and Solid Wood Wall Materials—Quality, Specifications and Comparison to Furniture Finishing Techniques; George Holman, Manager, Cooperage Division, Hiram Walker & Sons, Inc., Problems Associated with the Procurement of Tight Cooperage Stock; and P. A. Price, Caterpillar Tractor Co., Harvesting Pulpwood. An open forum will be held on subjects covered by these papers.

Employer–Employee Relationships under Current Labor Relations Laws will be the topic of the principal luncheon speaker, Homer Keller, member, Miller–Westerfield, Thomason and Johnson.

Plant tours are scheduled in the afternoon to Barrett Division, Allied Chemical and Dye Corp., manufacturers of roofing felt from local hardwoods; and Hiram Walker & Sons, Inc., one of the world's largest distilleries.

Special invitations to attend the meeting are being sent to directors of research of pulp and paper mills throughout the Great Lakes region.

FPRS Salutes . . .

Men Who Are Contributing Their Time and Efforts for the Furtherance of the Society and the Wood Industry

R. H. BERRY

Raymond H. Berry—facing the $60,000 challenge. Raising $60,000 within the next 90 days is the task facing Ray Berry—that's the goal the FPRS Executive Board has set in its drive for the new national office building fund. Now it's up to Ray, as fund-raising chairman, to obtain the cooperation of FPRS members and wood industry firms to meet that goal. You don't often associate a top college athlete with being a standout in the classroom, but Ray was just that. He was a member of the varsity wrestling team at Yale University, and elected to Phi Beta Kappa in his junior year. He also found time to sing with the renowned Yale Glee Club. He later attended the Sorbonne in Paris and received an LL.B. degree from the Yale Law School. After 13 years as a lawyer in New Jersey, Ray followed in his father's footsteps in the lumber business, forming the Scott Lumber Co. at Burney, Calif., serving as agent for the Swift Starr Davies Timber Ownership, and organizing Long Valley Building Materials, Inc., and serving as its secretary. He further demonstrated his versatility by serving as president and director of the Shasta County, Calif., Bank since its beginning in 1952, as president of the Burney Chamber of Commerce, chairman of the county Republican committee and member of the state committee, and president of the board of trustees of his church. Ray is a member of 13 business organizations, four fraternal groups and eight social organizations. Active in FPRS work, he served as chairman of the Southwest Section in 1950–51 and presently is the Southwest Regional Board Member.

P. H. GRAHAM

Paul H. Graham—getting FPRS "Buffalo-minded" is his job. Expected attendance at the National Meeting in Buffalo rides on Paul's shoulders. No matter how fine the technical sessions are, the meeting won't be a success unless several hundred FPRS members and guests attend. That's where Paul comes in as publicity chairman—sending information to all the wood industry trade journals. Have you seen the "Did This Problem Have You Buffaloed" series appearing in leading trade journals. Paul wrote the series as an information service as well as to make the wood industry "Buffalo-minded". This isn't the first time Paul has done a bang-up job of arousing interest in Society activities. He's a charter member of FPRS and one of the leaders of the Northeast Section since its inception in 1948. His work as membership chairman has been instrumental in the Section becoming the largest in the Society. His efforts as publicity chairman have stirred interest in the Section's program. Paul is an experienced hand in such public relations work. A well-known author and contributor to wood industry journals, he has had more than 30 years' experience in the woodworking field.

C. R. LOCKARD

Charles R. Lockard—squeezing 12 months' into six days. The National Meeting will last six days, but for Charlie Lockard that will mean more than 12 months of intensive work. As general chairman for the affair, Charlie has been actively supervising the efforts of 20 committee chairmen during the past nine months. Overseeing successful FPRS activities is nothing new for Charlie. He is a charter member, served as Chairman of the Northeast Section, and currently is Northeast Regional Board Member. Chief of forest utilization service, Northeastern Forest Experiment Station, Upper Darby, Pa., Charlie was a technologist at the Southern Forest Experiment Station in New Orleans before being appointed to his present post. He has had more than 20 years' experience in federal and state forest administration and industrial forestry.

N. A. NORTON

Newell A. Norton—planning the wood industry's future with today's students. Keeping pace with technological advancements is a must for any industry, and such progress is dependent upon developing trained leaders. Newell Norton has recognized this need and through his efforts college students are given an opportunity to spend their summers working for wood industry firms, gaining valuable experience and training and contributing their knowledge. Newell began this program last year. Encouraged by its success he again is contacting wood industry firms and colleges, with more than 30 schools in the U. S. and Canada and 40 companies already expressing interest. The summer program is another example of the excellent work performed by Newell as chairman of the FPRS Employment Committee. A charter member of FPRS, he is a Northeast Section board member and co-chairman of the Section's education committee. He has had more than 25 years' experience in forest products and allied fields, including service at the U. S. Forest Products Laboratory, consultant to private industry, and research at the University of Michigan and Pennsylvania State University. Newell presently is head of the Department of Wood Utilization at Penn State. He received a Ph.D. from Brown University, M.F. from the Yale School of Forestry, and Ph.D. from Michigan.

Session Themes

(Continued from page 9-A)

dryers and furniture manufacturers. Closely related will be the panel discussion on stacking practices and lumber stickers. Survey results relating to sticker costs and use will be summarized, and sticker breakage, thin vs. thick stickers, and their effect upon lumber drying will be discussed.

Wood Finishing

F. H. Thomas, Session Chairman. Tuesday, June 25, 2:45–4:45 p.m.

There'll be something for everyone concerned with finishing at this session. Because of diversity of interest, important phases of each field of finishing will be covered.

Two papers will cover the important subject of exterior house paints. There has been a definite trend towards blister-resistant paints, and some 125 companies now are making paints of this type. A report on a 21-month exposure test to determine the exposure characteristics of clear finishes for exterior wood finishes will be given. This should be of considerable popular interest since there is so much natural finishing of ranch-style homes.

Another paper will cover the factors that fillers contribute to the quality and appearance of the wood finish. A report on various factors contributing to the color of a finish will be presented, covering wood selection and preparation, finishes materials selection and testing, application of finish, and inspection as a factor in color control.

Wood Machining

L. A. Patronsky, Session Chairman. Tuesday, June 25, 9:00–11:30 a.m.

The purposes for machining wood have remained the same for more than 50 years, but the first half of the 20th century has brought about tremendous changes in materials for building machinery, lubricants, motors and controls, and especially in tool steels.

Productivity has been improved and many hazards have been removed, making the operation safe and clean. Present day dimensional accuracy requirements for laminating, veneering and moulding have necessitated the use of precision gauges and micrometers for grinding and setting up cutterheads, and for use in the control of quality.

The papers presented at this session will discuss the present status of productivity and maintenance of

L. A. PATRONSKY

I. HATFIELD

wood working machines, and look at the future of wood machining research and engineering development.

Wood Preservation

Ira Hatfield, Session Chairman. Wednesday, June 26, 9:30 a.m.–12 noon.

Papers and discussion at this session will point up research findings with reports on commercial activities. Special attention will be paid to cellulose preservation problems not covered previously at other meetings. The speakers will present new and applied information on methods of evaluating and use of wood preservatives, as well as progress reports on current research and commercial activities in the preservation field.

Throughout the entire session, primary emphasis will be placed on the importance of research. In the past the stress has been on commercial application, but this year developments in all phases of wood preservation will be thoroughly discussed.

Particle Board Is Theme of Northern Calif. Section Meeting at Berkeley May 2–3

All aspects of particle board production including raw materials, quality control, production processes, economics, and marketing will be discussed at the Spring Meeting of the Northern California section to be held May 2–3 at the Claremont Hotel, Berkeley, Calif., according to Robert M. Kuhn, Section Secretary-Treasurer.

Speakers at the meeting and their topics will include: Raw Material Available for the Particle Board Industry, L. N. Ericksen, California Forest and Range Experiment Station; Mill Residual Balance, Henry Sandstrom, Diamond Match Co.; Choosing a Log Barker, Douglas L. Hunt, Western Pine Association; Particle Board Processes, Dr. George Marra, Washington State Institute of Technology; Quality Control in the Particle Board Industry, Warren C. Smith, U. S. Plywood Corp.; Adhesive and Adhesion Problems in connection with Particle Board Production, Dr. J. E. Marian, University of California Forest Products Laboratory; Economics of a Particle Board Operation, Donald R. Seip, Donald R. Seip Co.; Research Program in Connection with Particle Board, Clark C. Heritage; Use Development for Particle Board, Wayne C. Lewis, U. S. Forest Products Laboratory.

Other highlights of the meeting will be a dinner address by Paul R. Bonderson, California State Water Pollution Board, on the functions of the control board, use of streams and tidewater for effluent disposal, and procedures of a wood utilization plant involving disposal of wastes. The meeting will also include a visit to the University of California Forest Products Laboratory, to observe and discuss research in progress.

May 1 Is Final Date to Enter Wood Award Contes

The deadline for entries in the 1957 Wood Award Competition is approaching, A. J. Panshin, chairman of the FPRS Industry-Education Division, has announced. All students wishing to take part in the competition are urged to immediately contact the FPRS Executive Secretary, P. O. Box 2010, University Station, Madison 5, Wis. May 1 is the final date for submission of complete papers, which must be submitted in triplicate.

Duke University has joined the list of schools reporting students tentatively planning to enter the competition. University of Michigan, Yale University, University of British Columbia, University of Toronto, Iowa State College, and State University of New York College of Forestry previously indicated possible entries from their student bodies. Tentative titles received since the last report in the February JOURNAL include: An Accelerated Wood Preservative Termite Study, The Relation of Wood Properties and Nosebar Pressure in Production of Veneer, and Quantifying the Topography of Wood Surfaces.

The Wood Award competition, sponsored by Wood and Wood Products magazine, is open to graduate students in attendance for at least one quarter or semester at any North American university or college between January 1, 1956 and April 30, 1957. The first place winner will receive $350 and will be invited to present his paper at the FPRS Eleventh National Meeting June 23–28 in Buffalo. The second place winner will receive $150.

Six Firms Giving Door Prizes at Buffalo Meeting Announced

Six firms have already promised to donate door prizes to be awarded at various events during the Eleventh National Meeting June 23–28 in Buffalo, according to David Swanson, chairman of the prize committee.

The following lists the prizes and sponsoring firms to date: one table, Norquist Products; two pull-up tables, Union–National Furniture Co.; one Williamsburg table, Kittinger Co.; one Barcalounger, Barcalo Manufacturing Co.; two chairs, Sikes Co.; one set Melmac dinnerware, American Cyanamid Co.

Thompson Elected Eastern Canadian Section Chairman

New officers were elected and six cash awards were presented to university undergraduates at the annual meeting of the Eastern Canadian Section March 7–8 in Montreal. Highlighting the annual dinner was an illustrated talk by Col. J. H. Jenkins, Chief, Forest Products Laboratories of Canada, who spoke on his recent tour of the timber-producing industries of Russia.

Section officers for the coming year are: Chairman, E. A. Thompson, Canada Creosoting Co.; Vice-Chairman, Georges Roy, Plywood Associates, Inc.; 2nd Vice-Chairman, G. S. Billington, Moore Dry Kiln Co., Ltd.; and Past Chairman, Kenneth O. Roos, Booth Lumber Limited. R. F. DeGrace, Canadian Institute of Timber Construction, and Peter M. Morley, Canadian International Paper Co., are continuing as Secretary and Treasurer.

Elected trustees were J. Clive Reade, Canadian Woodworker; H. C. Knight, Knight Mfg. and Lumber Co.; and Maurice Gerin, Quebec Lumber Manufacturers Assoc. Fred N. Walsh, A. S. Michell, Clayton Allgeier, and G. W. Hossack remain in office as trustees, while Louis Roy will continue as Membership Chairman and Col. J. H. Jenkins as Chairman of Awards.

The student awards are given annually to encourage interest in the preparation of technical papers in the forest products field and on the use of wood as an engineered material. The competition is open to undergraduate students at all universities within the Eastern Canadian Section.

This year's winners of the six awards of $50 each were: H. J. Porter, R. L. Vatcher, and A. W. Worth, N. S. Technical College, "Preliminary Investigation of a 12-foot Span Built-up Plywood Web Douglas Fir I–Beam with Diminished End Sections"; A. W. Porter, U. of New Brunswick, "Methods of Applying Wood Preservatives"; R. Langlois, Laval University, "Tableaux de Sechage des Bois"; K. Poole, McGill University, "Influence of Prehydrolysis on the Degree of Polymerization and Carbohydrate Composition of Southern Gumwood"; P. Jaciw, University of Toronto, "Economic Considerations of Wood Waste Utilization for the Production of High Quality Building Materials—An Outstanding Example—Lightweight Concrete Du-Al Block"; and Structural Design Class Project, University of Manitoba, "From Rectangular Plywood Sheets to Two-Thirds Sphere"

INDUSTRY NEWS

Syracuse Forestry College Dedicating New Laboratory

Dedication of the new forest products laboratory of State University of New York College of Forestry at Syracuse will be held May 2–3, Dean Hardy L. Shirley has announced The Hugh P. Baker Laboratory building will house the Departments of Forest Utilization, Wood Technology, Forest Chemistry, and the newly organized Cellulose Research Institute.

Program for the dedication ceremonies will consist of a symposium on "Forest Products in Today's World" and a banquet on May 2, and will conclude with formal presentation and acceptance of the building on May 3. Frederick S. Crysler, Manager, Eastern Division, Container Corp. of America, is chairman of the dedication activities.

Speakers scheduled to participate in the symposium include: Richard E. McArdle, chief of the U. S. Forest Service, Washington, D. C., "Forest Products—Key to Forest Management"; S. W. Antoville, president, U. S. Plywood Corp., "Research for Wood Products"; O. H. Alderks, vice-president in charge of research and development, Buckeye Cellulose Corp., Memphis, Tenn., "Research for Cellulose Products"; and George A. Garratt, dean, Yale School of Forestry, "Education for Forest Products Leadership."

"Research in Forest Products for Tomorrow's World" is the title of the keynote address to be given at the banquet by David L. Luke, Jr., president, West Virginia Pulp and Paper Co. The "Purpose of Baker Hall" will be discussed in three brief after-dinner talks by Judge Francis D. McCurn, past chairman of the College's Board of Trustees; Syracuse University Chancellor William P. Tolley, and Dean Shirley.

New York's Governor W. A. Harriman will present the new $3.75 million building to the State University of New York at the official dedication ceremony on Friday. Dr. William S. Carlson, president of the University, will accept. The ceremonies will conclude with guided inspection tours of the building.

Tests for Particle Board Described in New Booklet

Suggested methods for sampling and testing wood particle board are covered in a new publication of the National Woodwork Manufacturers Assoc., 332 S. Michigan Ave., Chicago. Copies of the bulletin, Recommended Testing Procedures for Wood Particle Board, may be obtained for 50¢ each.

Sixteen tests are outlined in the book, prepared by the NWMA Wood Particle Board Committee to assist the industry in correlating research and testing of particle boards. Participating in an advisory capacity were the U. S. Forest Products Laboratory and Timber Engineering Co. ASTM tentative

Designed for education and research in forest products, the new Hugh P. Baker Laboratory at State University of New York College of Forestry will be dedicated May 2–3.

methods were the source for a major portion of the recommended procedures.

Forest Products Marketing Data Sources Surveyed

Marketing information available to forest owners is summarized in results of a survey made by the Forest Industries Council, 220 E. 42nd St., New York, N. Y. A tremendous degree of interest in the forest products marketing field was disclosed by the study. Every state except Arizona, Nevada, and New Mexico publishes market information to aid forest owners. In addition, information is published by federal agencies, wood-using industries, trade magazines, professional journals, regional and state forestry organizations.

A bulletin summarizing the survey describes organizations which provide some form of marketing advice or assistance and lists their activities. The survey demonstrates that a sound program for establishing and improving marketing and price reporting services may develop the following features: a directory of buyers of forest products; periodic review of market demand and supply, price trends, and major price changes by areas; published material explaining good harvesting and marketing practices; personal advice of private and public foresters; price reporting by a marketing committee with representatives of both buyers and sellers of forest products.

Two Courses Given for North Carolina Sawyers

Sawmill demonstrations were conducted in Lenoir and North Wilkesboro, N. C., last month by the Furniture, Plywood & Veneer Council of the N. C. Forestry Assoc., U. S. Forest Service, and Tennessee Valley Authority. The meetings were held to promote better manufacture of hardwood lumber and sawing to improve lumber grades produced.

Hardwood log grades, log bucking, selection of mill sites, and layouts, as well as air seasoning, were discussed by Walton R. Smith, Southeastern Forest Experiment Station. J. A. Curry and W. W. King, Tennessee Valley Authority, covered log and lumber grade yields, the comparative results of a 5-year mill efficiency study, and sawmill costkeeping.

Fred B. Malcolm, U. S. Forest Products Laboratory, reviewed sawmill equipment, power needs, efficient use of manpower and machines, mill alignment, saw problems and maintenance, and trouble shooting at the sawmill. Smith and Malcolm also gave demonstrations on log grading and grade sawing at local sawmills.

American Laminated Members Helping Restore Ancient Stoa

The Greek Stoa of Attalos, which before 267 B. C. was one of the buildings which formed the cultural and political heart of ancient Athens, is being completely rebuilt and restored at the original site. The original timber roof beams will be simulated by laminated wood members designed by Rilco Laminated Products, Inc., Albert Lea, Minnesota.

Excavations begun 25 years ago at the site by the American School of Classical Studies unearthed more

than 60,000 items dating from 6000 B. C. and included statues, vases, metallic pieces, as well as whole structural members which made it possible to reconstruct on paper the complete Stoa. The restored Stoa will be a museum housing the thousands of priceless treasures which once graced this center.

Mountain Hemlock to Be Tested for Commercial Uses

Strength and related properties of mountain hemlock are to be tested for commercial uses by the U. S. Forest Products Laboratory at Madison, Wis., the Pacific Northwest Forest and Range Experiment Station, and the Oregon Forest Products Laboratory. Most likely use of the species, scientists say, would be in the manufacture of small log dimension lumber and possibly wood chips.

The species differs from Western hemlock in that it grows at higher altitudes and is limby and smaller. Although it has little commercial value at present, the wood is close-grained, a desirable feature in other sawtimber species, J. D. Snodgrass, research coordinator at the Oregon Forest Products Laboratory, points out.

Mountain hemlock grows at elevations from 4500 to 6500 feet, and ranges in size from 10 to 30 inches. However, trees over 20 inches are often attacked by Indian paint fungus. The species grows in the Cascades of Oregon and Washington, extending into Alaska, with an estimated 4.5 billion board feet in Oregon alone.

Narrow Width Siding Making a Comeback

Narrow widths of bevel siding appear to be regaining popular favor among home builders. This is a natural trend, as a large percentage of today's houses are relatively small and rabbetted bevel siding in widths of 4 and 6 inches make these small houses appear larger and more imposing.

Wide bevel siding is fine for large houses as it gives them an appearance of compactness and neatness, but this same wide siding appears out of place on small houses and it makes them look even smaller. This aesthetic consideration is also true of vertical board siding. Narrow vertical boards make a small house look longer and taller. Likewise small rooms appear larger when panelled with narrow patterns.

Cost is probably another influencing factor with the builder as wide siding and boards are about 50 per cent more costly for material. Some of these savings are lost by higher installation labor costs, but the final monetary advantages still favor the narrow siding and panelling.

New England Kiln Dryers Schedule Spring Conference

"Wood Will Always Have to be Dried" is the theme of the New England Kiln Drying Association Spring Conference scheduled to be held May 10–11 at the New Hampshire Highway Hotel, Concord, N. H. The conference is being sponsored by the New Hampshire Manufacturers Association.

Further details of this conference and of a six-day seasoning clinic to be held in September at Amherst, Mass., will be available in a few weeks, Harry Rich, Secretary, announces. He urges those interested to contact him at Conservation Building, University of Massachusetts, Amherst, Mass.

Polymer Plant in England Opened by National Adhesives

A polymerization plant is being erected in Slough, England, by National Adhesives Ltd., English affiliate of National Starch Products, Inc. The new plant is expected to start operation next month, according to Managing Director R. M. L. Francis.

It is planned to produce polymers of vinyl acetate for use in the packaging, paper, textile, coating, and paint fields. Facilities will also be provided

fo production of formulated resin ad sives.

ncluded in the construction is the er tion of a new laboratory to house th expanded development, service, a control facilities. Plans are also b g made for a new adhesive manu- f uring plant and office building.

N C. State Conducts Marketing Institute

umber and building supply firms' e loyees from throughout North C olina met Jan. 14–25 at N. C. S te College for the annual Retail F lding Supply Marketing Institute. D scussions centered around preven- t of decay and termite damage, w d preservatives, and planning of f n buildings for present and fu- ture needs. The remainder of the m eting dealt with fundamentals of m dern retailing.

Sponsors for the two-week course w re the Carolina Lumber and Build- ing Supply Association, N. C. State College School of Forestry, and the College's Extension Division. Roy M. Carter, prof. of wood technology, was in charge of the program.

Nail-Glued Hip-Roof Truss Design Developed at Illinois

A design which permits hip roofs to be built with nail-glued trusses has been released by the University of Illinois Small Homes Council, Urbana. Directions for building the trusses for spans of 21 feet to 28 feet 8 inches are presented in an instruction sheet prepared by Howard E. McCall and James T. Lendrum, architects on the Small Homes Council staff.

The truss, which is for a 3-in-12 inch slope, is the newest of the Council's truss designs utilizing the nail-glued technique developed by the Council and Purdue University. The truss system uses flat-top trusses spaced 2 feet on center. Terminal truss supports and jack rafters used in conventional hip-roof construction are eliminated.

An instruction sheet, which shows the geometry of the trusses and complete details for assembling them, is available for 25 cents from the Small Homes Council, Mumford House, University of Illinois, Urbana.

Firm Changes Name and Elects New Officers

E. S. Evans, Jr., president of Evans P ducts Co., Plymouth, Mich., has a ounced that the firm's subsidiary, H co, Inc., has changed its name to H skelite Manufacturing Corp. R. B. E ns, vice-president of Evans Prod- s, was elected president and treas- r of the new Haskelite Co.

Acquisition of the assets of the old Haskelite Company, including its four plants, brings to eleven the number of plants now owned by Evans and its subsidiaries in the U. S. and Canada. Haskelite, which manufactures doors, door units, and laminated wood products, operates a plant at Grand Rapids, Mich., and three subsidiaries at Mobile, Ala.; Marquette, Mich.; and Sault Ste. Marie, Canada.

Arkansas Flakeboard Plant Nearing Completion

Production is scheduled to start this month at the nation's first homogenous flakeboard plant, United Wood Corp., West Memphis, Ark., according to Wilco Machine Works, Inc., which is engineering the plant and providing all equipment.

D. N. Copp, president, said the plant will use Southern soft hardwoods, purchased as pulpwood, to manufacture a variety of thicknesses and densities in flakeboard. The board is reported to be characterized by its superior strength, screw-holding, and finish properties.

A five-opening 5- by 16-foot Siempelkamp hot plate hydraulic press will produce some 50 tons of flakeboards per 24-hour day. The 13-acre plant grounds and 24,000 square foot building were made available to the firm by the Arkansas Industrial Development Commission.

Summer Statistics Session Offered at Virginia School

The fourth Southern Regional Graduate Summer Session in Statistics will be held June 12 through July 20 at Virginia Polytechnic Institute, Blacksburg, Va. Courses scheduled to be given include Sampling of Biological Populations, Analysis of Variance, Rank Order Statistics, Stochastic Processes, Probability, Statistical Inference, Theory of Least Squares, Statistical Methods, Engineering Statistics, and Sampling. Seminars on some of the more recent research now being carried on in the statistics field will be conducted Monday through Thursday afternoons from 3 to 4:30.

The Southern Regional summer sessions may be entered at any session, and consecutive courses are offered in successive summers. The summer work in statistics may be applied towards residence requirements at any of the cooperating institutions, University of Florida, North Carolina State College, Oklahoma A & M, and VPI, as well as certain other institutions. Each course offered carries approximately five quarter hours of graduate credit.

Tuition fee for the six-week term is $38. Inquiries should be addressed to Boyd Harshbarger, Head, Department of Statistics, Virginia Polytechnic Institute, Blacksburg.

NAMES IN THE NEWS

J. C. Daugherty, president of Hoosier Veneer Co., Indianapolis, Ind., has been elected president of the American Walnut Manufacturers Assoc. Other new officers are: vice president, **J. B. Petrus, Jr.**, Midwest Walnut Co.; treasurer, **G. W. Hartzell**, Hartzell Industries.

Trustees of American Forest Products Industries, Inc. announce election of **Vertrees Young**, president of Gaylord Container Corp. Division of Crown Zellerbach Corp., Bogalusa, La., as president. He succeeds the late **J. P. Weyerhaeuser, Jr.**

Opening of a consulting service to the forest industries in Spokane, Wash. is announced by **I. V. Anderson**, former chief, Forest Utilization Service, Intermountain Forest and Range Experiment Station, Ogden, Utah. He will specialize in production and wood use problems, woods and mill utilization studies.

I. V. ANDERSON

R. G. KIMBELL

Richard G. Kimbell, NLMA vice-president of technical services since 1934 and a veteran of 38 years' service with the association, has been appointed acting executive vice-president of the National Lumber Manufacturers Assoc.

Appointment of **Monroe W. Pollack**, vice-president of U. S. Plywood Corp., as its director of sales has been announced by **S. W. Antoville**, president. Pollack previously was in charge of special product sales and has been with the firm for 36 years.

Advancement of **William N. Pauley** to partner in the firm of **H. E. Bovay, Jr.**, consulting engineers, has been announced by Mr. Bovay. Pauley is in charge of the Spokane, Wash. branch office of the firm, which maintains headquarters in Houston, Texas.

William C. Anderson has been named general manager of lumber marketing for Hardwood Corp. of America, Asheville, N. C., according to **John B. Veach**, president.

M. R. Childs has been appointed associate wood utilization technologist, Forest Products Dept., Texas Forest Service, Lufkin. A graduate forester, Childs received M. S. in

wood technology this year from N. C. State College, Raleigh.

New president of the Furniture Club of America is **A. A. Laun, Jr.**, president of A. A. Laun Furniture Co., Kiel, Wis., and a Wisconsin State Senator. Other new officers are: **A. A. Christensen,** 1st vice-president; **C. R. Chatel,** 2nd vice-president; and **R. E. Harland,** 3rd vice-president.

Marvin A. Ring, former instructor in civil engineering at Oregon State College, has joined Mater Engineering, Corvallis, Ore., as chief engineer. He recently spent several months assisting Diamond Match Co. in the design of an integrated forest products plant at Red Bluff, Calif.

Heading research in timber physics at the U. of California Forest Products Laboratory is **Eric L. Ellwood,** former staff member of Commonwealth Scientific and Industrial Research Organization, Melbourne, Australia. Ellwood received Ph. D. from Yale University, was 1953 winner of the Wood Award.

W. C. Kelso, Memphis, Tenn., has been awarded the Chapman Chemical Co. Graduate Research Fellowship at U. of Minnesota School of Forestry. Research under this award is aimed toward basic problems relating to use of pentachlorophenol as a wood preservative and will be under the direction of **Dr. Frank H. Kaufert,** director of the Minnesota School of Forestry.

W. C. KELSO, Jr.

K. G. CHESLEY

Chesley Named to TAPPI Executive Committee

Kenneth G. Chesley, past president of FPRS, has been elected a member of the Executive Committee of the Technical Association of the Pulp and Paper Industry. He will serve a three-year term on TAPPI's 11-man governing body.

Director of Research for Crossett Lumber Co., Crossett, Ark., Chesley is a charter member of the Society. He served as South-Central Regional Board Member and Vice-President before becoming FPRS President in 1952. Chesley received an A. B. degree from University of Kansas and M. S. from Lehigh University before joining Crossett.

E. S. Harrar Named Dean of Duke Forestry School

Dr. E. S. Harrar has been named dean of the Duke University School of Forestry, University President Hollis Edens has announced. Dr. Harrar succeeds Clarence F. Korstian, the school's founding dean.

Formerly professor of wood technology at Duke, Dr. Harrar is a specialist in the structural, physical and chemical properties of woods. He was recently appointed to the Task Group on Forest Products of President Eisenhower's Commission on Increased Industrial Use of Agricultural Products.

Active in FPRS, Dean Harrar is a former member of the Executive Board and currently is a candidate for Vice-President. He holds B.S., M.S., and Ph.D. degrees from the New York State College of Forestry. Before coming to Duke in 1936, Dr. Harrar taught at the University of Washington. During World War II he served as chief administrative engineer with the Airplane Division of the Curtis–Wright Corp., Louisville, Ky.

NEW PRODUCTS—LITERATURE

New Moisture Detector

Laucks Laboratories Inc., Seattle, Wash. has announced its 1957 series Sentry Continuous Moisture Detector. The units are of modular design, with each primary circuit housed in an interlocking, pull-out type "drawer." Service problems are reduced to a simple change of drawers, the manufacturer reports, while an expansion of the system for additional dry lines may be accomplished by adding drawers.

The changeover in design will permit installation of Sentry equipment in areas, both foreign and domestic, which heretofore lacked proper service facilities, John T. Laucks, president of the Seattle laboratories announced.

Wood Chip Transport

An automatic, self-unloading transport body designed primarily for the delivery of bulk wood chips is announced by Baughman Manufacturing Co., Jerseyville, Ill. Available in body lengths from 12 to 34 feet, the Model WC–8 Wood Chip Transport Body features four chain and flight conveyors which cover the width of the body bottom.

The open van-type body reportedly permits quick loading from either buckets or wood chippers at the site. The discharge shaft on the unloading conveyors permits fast, easy connection to a stationary power source. Built-in hydraulic operation is also available for smaller operations, or where several unloading areas are necessary.

Small Log Debarker

A new small mill log debarker designed for mills producing from 10,000 to 20,000 board feet per day has been developed by Nicholson Manufacturing Co., Auburn, Wash., and is being distributed by Wilco Machine Works, Inc., Memphis, Tenn. The machine is designed to fill the gap between a slab barker and round log debarker both in terms of productive capacity and initial investment.

The barker operates by four thick, blunt blades on a revolving head suspended on an arm which moves across the length of the log underneath it while the log is rotated by a series of rolls. The distributor reports negligible fiber loss due to the wrist action of the head arm. The debarker will be available in two models for 20- and 24-foot logs, and both models will accommodate logs from 6 to 28 inches in diameter. Total horsepower is 21 hp.

New Taper Clutch

An automatic taper clutch which makes taper sawing practical for all sawmills has been developed by Mater Machine Works, Inc., Corvallis, Oregon. Designed for all mills, the taper clutch can be installed by the mill operator over a week-end shut down, using installation blueprints supplied with the machine.

The new taper fits into the setshaft between the headblocks on any sawmill log carriage. When the sawyer or setter is ready to taper, he pushes a toggle switch which disengages the clutch so that he can move one or more knees independently. The independent knees can be moved any distance forward or backward to fit the log taper. When the log face is parallel to the sawline, the sawyer releases the toggle and the setshaft locks again, ready for setting out the knees in their tapered position.

Engineered for operation by either the setter or the sawyer, using the same power source as the setworks, the Mater taper clutch is available in two standard sizes. It can be set up in

different ways to suit the mill tapering practice and to tie in with the setworks drive. Air operated and electrically controlled, the clutch unit has been field tested in selected sawmills in several regions.

Knife Grinding Instructions

Instructions on the development and grinding procedure for shaper knives is available from Wisconsin Knife Works, Box 309, Beloit, Wis. The four-page booklet is also applicable to any ground-to-pattern knife that would be used in round or square heads, whether used on shapers, stickers, moulders, tenoners, or any other type of machine used for cutting a pattern on a piece of wood.

The illustrated booklet also contains recommendations on types and uses of grinding wheels, and a list of standard safety code regulations for woodworking machinery.

Plywood Grooving Machine

A specially designed V-grooving machine which will reportedly reduce the cost of V-grooved plywood to the consumer and yet maintain greater profit margins for the wholesaler and dealer has been developed by the Hi-Grane Board Co., Fort Worth, Texas. The Myers self-feeding plywood V-grooving machine is capable of grooving approximately 20,000 feet of wood in eight hours.

The 800-lb. machine is delivered with casters for easy movement within buildings, and is described as "the machine that was invented to solve an inventory problem." Ungrooved plywood in a wholesaler's or retailer's stock is completely V-grooved in a few seconds time, ending the need for separate stocks of grooved and ungrooved plywood. With aprons extended the machine requires 12-foot by 5-foot space plus room to work the plywood.

Fireproofing Resin

Fireproof paper that will also withstand outdoor exposure is now possible by the use of Synco 85, a new impregnating resin, according to R. F. Gager, Vice-President of Synco Resins, Inc., Bethel, Conn. These papers reportedly show the increased strength and heat and chemical resistance characteristic of phenolic-impregnated materials.

The papers are claimed to be resistant to high humidity and good resistance to water immersion or outdoor exposure is obtained by the use of a light size coat. Papers produced with this new resin are said to be adaptable for insulation and structural materials such as honeycomb cores, overlays, and laminates.

Hydraulic Press Catalog

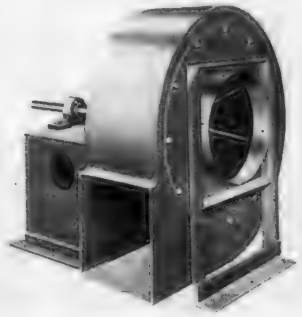
A 16-page catalog describing presses for producing veneer, plywood, chip board, and plastic laminates is available from Fjellman American Inc., 105 Republic Ave., Joliet, Ill. The booklet describes and illustrates exclusive design features of Fjellman presses, showing many in-plant installations.

Detailed specifications and cross-sectional drawings of platen construction, assembly and automatic controls are also contained in the catalog. Special sections are devoted to door presses and loading equipment, particle board presses, and the Fjellman Autoloading shuttle feeder. The catalog also lists sizes and specifications of all standard hot plate presses manufactured by the firm.

Heavy Duty Exhaust Fans

A new line of heavy duty exhaust fans is announced by Dependable Machine Co., Inc., Greensboro, N. C. They are designed specifically for removal of sawdust, shavings, chips, dust, and wood scraps in woodworking plants and sawmills.

Reported features of the fans include: removable side plates so that the housing may be rotated, interchanging side plates which allows rotation of the fan to be changed, statically and dynamically balanced wheels, and dustproof ball bearings.



The fans are made in standard, 6-blade models from #20 to #80 sizes, and in slow speed, 12-blade models from #30 to #80 sizes. Illustrated bulletin C—11–B giving complete information and specifications is available from the manufacturer.

NEW PUBLICATIONS

Determination of Moisture in Solids. P. J. Geary. British Scientific Instrument Research Association publication surveys known methods of determining the moisture content of solid materials and lists instruments and other apparatus for making measurements of moisture content. Available from the publisher, Sira, South Hill, Chislehurst, Kent. Price $1.33 cash with order.

The Chemical Formulary, Volume X. Contains new formulas in fields of adhesives, materials of construction, paint, varnish and lacquer, paper, and others. $8.00. Chemical Publishing Co., Inc., 212 Fifth Ave., Dept. 274, New York 10, N. Y.

1956 Supplements to Book of ASTM Standards. Part 4. Paint, Naval Stores, Woods, Sandwich Construction, Building Constructions, Fire Tests, Wax Polishes. Includes 78 standards covering white pigments; drying oils, paint driers, and thinners; shellac, varnish, and resinous materials; lacquer materials; general paint tests; paint weathering tests; naval stores; cellulose and cellulose derivatives; wood and wood preservatives; fire tests. 230 pages. ASTM, 1916 Race St. Philadelphia 3, Pa. Price, $4.00.

Green Gold — Opportunities for Wood-Using Industries in Southeast Kentucky. Information on the 65 million board feet of sawtimber and 500,000 cords of pole timber available in the southern section of the Cumberland Plateau, Ky. Published by Kentucky Bankers Association, Hilliard Building, Louisville.

Cost Estimating for Wood Industries. L. D. Coolidge and J. R. Pfeiffer. Outlines means for making early cost estimates where little cost information is available, and lists procedures that can be used in preparing estimates of total plant cost, operating costs, and probable return on investment. Oregon Forest Products Laboratory, Corvallis, Ore.

Southern Appalachian Research Center. J. F. Renshaw. Describes experimental work being done in the Asheville area. Southeastern Forest Experiment Station, Asheville, N. C.

Preliminary Survey of Chip Size. G. N. Kemp, R. C. Sproull, and R. H. Stevens. Reprint from Tappi. Herty Foundation Laboratory, Savannah, Ga.

Forest History Sources of the United States and Canada. An indexed guide to unpublished manuscript source materials contained in the collections of 108 leading libraries and archives of the U. S. and Canada. Copies at $3 each are available from Forest History Foundation Inc., 2706 W. Seventh Boulevard, St. Paul 16, Minn.

How to Build Homes that Will Outlive the Mortgage. Booklet highlights survey and report made by AWPI engineers to assist the Building Research Advisory Board of the National Academy of Sciences—National Research Council in preparing its recent report to Federal Housing Administration. Single copies available without charge from American Wood Preservers Institute, 111 W. Washington St., Chicago 2, Ill.

Thickness and Density of Bark. J. D. Hale. Forest Product Laboratories of Canada, Department of Northern Affairs and National Resources, Ottawa, Ontario. Reprint from Pulp and Paper Magazine of Canada.

Cancer can't strike me, I'm hiding.

Cancer?

The American Cancer Society says that too many people die of it, NEEDLESSLY! That's why I have an annual medical checkup however well I feel. I know the seven danger signals. And when I want sound information, I get it from my Unit of the

AMERICAN CANCER SOCIETY

The following publications are available without charge from the U. S. Forest Products Laboratory, Madison, Wis.

Wood Siding—How to Install It, Paint It, Care for It. Home and Garden Bulletin No. 52. Describes kinds of wood siding, installation of siding, various types of finishes, paint primers, finish maintenance and finish troubles.

Influence of Rate of Loading on the Strength of Wood and Wood-Base Materials. L. J. Markwardt and J. A. Liska. Data are presented to show that the flexural strength of building fiberboards of the densities tested is increased as the rate of loading is increased. Reprint from the Copyrighted Symposium on Speed of Testing, published by the American Society for Testing Materials. 1956.

Loblolly Pine High Alpha Prehydrolysis-Sulphate Pulps. F. A. Simmonds, R. M. Kingsbury, J. S. Martin, and R. L. Mitchell. Reprint from Tappi.

Microbiological Process Report—Newer Preservative Treaments for Wood. R. H. Baechler. Describes the two-stage, double diffusion method of wood preservation developed at the U. S. Forest Products Lab. Reprint from Applied Microbiology.

ASTM Wood Pole Research Passes Half-Way Mark. A. D. Freas. Progress report on ASTM's study on safety and economy in use of wood poles. Reprint from Electric Light and Power Industry Report Issue.

Materials of Construction—Wood. R. H. Baechler, R. F. Blomquist, and Harold Tarkow. Covers developments in wood products during the period April 1954 to April 1956. Reprint from Industrial and Engineering Chemistry.

Supplement to Interlaminar Shear Strength of Glass-Fiber-Reinforced Plastic Laminates. R. L. Youngs. Presents the results of tests to determine the interlaminar shear strength of 3 epoxy laminates reinforced with 112, 120, or 143 Volan A glass fabric. No. 1848–A

Supplement to Elastic Buckling of a Simply Supported Rectangular Sandwich Panel Subjected to Combined Edgewise Bending and Compression. Results for Panels with Facings of Either Equal or Unequal Thickness and with Orthotropic Cores. W. R. Kimel. Report 1857–A

Courbaril. Foreign Wood Series. J. M. Kryn. Describes the color, mechanical properties, seasoning and shrinkage, resistance to decay and marine borers, working characteristics, uses and identifying features of Courbaril, family *Leguminosae*, spp *Hymenaea*. No. 1942.

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Properties of Particle Board Related to Its Use in Furniture Manufacture[1, 2]

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Properties of particle board for use as furniture core stock are compared with solid lumber core. Discussed are density, ease of veneering, surface qualities, dimensional stability, strength, stiffness, screw-holding ability, and machinability. Advantages as well as limitations of particle board in furniture manufacture are given.

Introduction

THE INDUSTRIAL EXPERIMENTAL PROGRAM at North Carolina State College, because of the current interest in particle board, has compiled a handbook[3] on the subject for furniture manufacturers and others concerned in the wood industry. This paper contains, in general form, some of the information included in the handbook relative to particle board properties.

The particle board industry in this country, while making rapid strides both from the standpoint of research and production, is yet in its infancy. It follows, then, that many mistakes have been and are currently being made. Also, the information available on the subject is often slanted and occasionally contradictory. This is normal, however, and various organizations are attempting to clarify the situation with proposed testing standards, etc. Accepted standards will be invaluable to both the producer and the consumer of the boards. Many furniture manufacturers are justifiably hesitant at investing in products and processes concerning which so little is standardized. Part of the fault naturally lies with the particle board producers themselves, many of whom have tried to oversell the product and make claims for it which are not valid.

The purpose of this paper, therefore, is to cover some of the ground concerning particle board properties, and to give some idea of its advantages as well as its limitations in furniture manufacture.

Density

Particle board density, of itself, and because of the influence it wields on the other physical properties of the board, ranks as one of the most outstanding of the various board properties; however, it also constitutes one of the principal limitations on the saleability of items constructed from it.

The prominence of density is readily appreciated following study of Fig. 1, which illustrates how bending strength increases with an increase in board density. Yet, particle board applied as furniture core stock should, according to current market conditions, possess a fairly low density. It is the consensus among experts in this country that the buying public will most readily accept furniture made with wood particle board when that board has a specific gravity between 0.55 and 0.80.

As mentioned, density has an important bearing on the strength qualities of the board. It is also related to the workability and ease of veneering as well as the properties of screw- and nail-holding ability, hardness, stiffness, and dimensional stability.

Furniture manufacturers who are not fully acquainted with particle board are inclined to judge the board on the basis of screw-holding ability, and consequently on the basis of density, since the screw-holding property increases with board density. This is a fallacy because, although the denser board does have better screw-holding ability, it possesses lower dimensional stability. This last factor may, of course, be more important to a furniture manufacturer than screw-holding ability, since screws are not applied to all surfaces and since there are often other methods of accomplishing the fastening.

The development of particle board has not reached the stage wherein the product can be manufactured in densities as low as might be desired in many applications and at the same time maintain the other physical properties at optimum levels. Undoubtedly, the near future will bring further important developments in the realm of adhesives and production techniques which, aided by research, will eventually allow the production of a board with the required qualities at a lower density. For the time being, however, since there is a dependence of the other physical properties on density for the production of a premium board, the customer will not invariably be able to acquire the board which would best satisfy his weight requirements.

Ease of Veneering

Since denser substances resist compression to a higher degree than lighter ones and since surface hardness is greatly dependent on density, it is thought that, upon application of pressures in the veneering process, better gluing will likely result due to the

[1] Presented at Session XI, Wood Composition Board, FPRS Tenth National Meeting, June 4-7, 1956, in Asheville, N. C.

[2] The paper was read by E. S. Johnson, professor of furniture manufacturing and management, N. C. State College.

[3] Wood Particle Board Handbook. 1956. Industrial Experimental Program, N. C. State College, Raleigh, N. C. 300 pp. $3.00.

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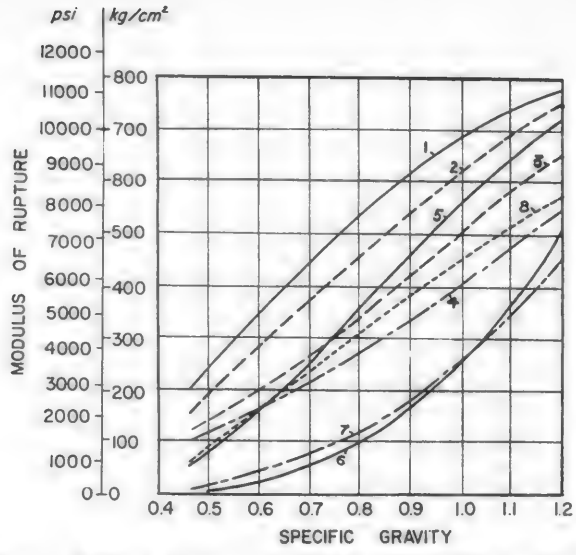

Fig. 1.—Modulus of rupture of particle boards depending on type of chip, type of wood, and specific gravity of boards (3).

Wood Species	Thickness	Type of Chips
1. Pine	.1 mm	Thin flakes (Specially cut)
2. Pine	.3 mm	
3. Pine	.5 mm	
4. Pine	1.0 mm	
5. Beech	.1 mm	
6. Spruce		Sawdust
7. Beech	1.5 mm	Coarse-ground furniture waste
8. Flax		Shavings

Binder: Phenolic Resin 8%

flattening out of the surface chips of the less dense boards, eliminating gaps and ridges which result in poor glue bond. The thermo-setting resins now in use are not satisfactory for gap-filling; however, a certain resin film thickness is necessary to provide optimum efficiency.

If these previous assumptions are valid, irregularities can be tolerated to a greater extent in lighter boards than in dense boards.

Surface Qualities

In the case of usage of chunky chips, some steps may be taken to produce a finer surface quality. Some board producers are trying to cope with this problem by retention of an amount of fines in the board mix. These fines help fill in the gaps in the board surfaces, thereby producing a smooth and even face.

Although these fines may weaken the board to some extent, absorb resin readily, and increase the density slightly, the advantages gained from eliminating rough surfaces are a must to prevent telegraphing or show-through once the veneer is applied. Telegraphing is, of course, not restricted to particle board only, but can originate in the cross-banding or veneer or in the application of either.

Dimensional Stability

Dimensional stability in wood is more pertinent in the manufacture of quality furniture than in any other application of wood products. Regulation and prediction of stability is more easily accomplished in a homogeneous mass such as particle board than in any but the highest quality wood. The natural variations in wood, caused by growth rings, knots, compression and tension wood, lightning scars, and pest damage, result in unpredictable changes. Of course, the yet imperfect techniques of particle board production leave much to be desired in the control of structural uniformity throughout, the two largest faults being settlement of fines and unevenness of mat formation prior to the application of heat and pressure.

The control of dimensional stability is partially accomplished by many manufacturers through the controlled use of additives which inhibit the moisture pick-up. This is basic, because the moisture change of wood substances causes expansion and contraction of wood cells.

Any means for effective reduction of the passages that lead into the board greatly assists in the minimization of moisture pickup. Factors which help accomplish this are those which serve to reduce the surface area of the wood particle, densify these particles, and cover the remaining surface areas which are available to moisture. The depth of additive impregnation of the particle, the permanency of the additives, and the nature of the moisture to be contended with are important in moisture control and consequently in dimensional stability control.

Direct expansion and contraction of the particle board, resulting from variances in moisture content, are not the only factors which determine the dimensional stability of the board. There are internal forces which are inherent in a compressed mass and may at any time be released; these forces, if released, will cause a dimensional change. This change in particle board is termed "springback." The most likely trigger for their release is the normal expansion and shrinkage caused by moisture change. These forces, when released, tend to allow the individual particles or chips to return toward a normal, uncompressed state. The dimensional changes, resulting in increased sizes, are annoying in close tolerance work.

Some manufacturers partially control springback by storing the boards, after curing, in a humidifier and subjecting them to controlled relative humidity cycles. The initial cycles probably release most of the springback tension. The veneering operation releases additional springback forces.

Other factors of springback control are resin amount and board density. Resin amount has not been proven to actually reduce springback, although a high amount of resin at least retards it. There is no direct correlation between density and springback, although the heavier boards will tend to springback more. One explanation offered for this is that the volume of voids in a lower density board partially absorbs the springback effect. Another is that more highly compressed particles themselves swell more, since all particles tend to reach their initial uncompressed dimension.

Strength

Many authorities feel that strength characteristics are greatly overvalued by the layman who is interested in particle board for furniture use. A common question asked about particle board is, "Is it as strong as lumber?", whereas the consideration for the strength required in furniture is forgotten.

Since strength characteristics are sharply dependent on density, which in turn is a primary consideration economically and technically, the strength requirements should be definitely known for intended end uses. Caughey (1) feels that a modulus of rupture of 1500 psi is necessary for quality panels that are to be veneered. Most commercial furniture core particle board is safely above this value. Veneering and crossbanding increases bending strength possibly threefold; whether this increase is necessary in most applications is unknown.

Other strength values which are deemed important are tensile strength, shear strength, toughness, hardness,

compressive strength, and modulus of elasticity. Caughey's recommended tensile strength is greater than 700 psi, which would appear sufficient in view of the lack of purely tensile forces in furniture uses.

Strength properties of particle board will limit the end uses. For instance, much present-day commercial board will not stand use as legs of chairs, etc., in standard shapes and sizes. Hardness is of importance when unveneered board is used, in order that indentations be resisted. Hardness, as well as the other strength properties except toughness, increases in general with board density and resin content.

The varied effects of production techniques on strength properties will not be discussed here, but it should be remembered that once a user decides what strength properties his board should have, it is fairly simple to obtain such a board, within reasonable limits.

Stiffness

Stiffness is important when the load to be applied is continuous. It is measured by initial deflection upon exertion of a force. The increase in deflection under a constant load is termed creep or sag. These two characteristics are important where particle board is used, for example, in shelving.

The Furniture Development Council of England(2) ran a series of tests dealing with these characteristics and determined recovery of deflection upon load removal and permanent deflection set. The test pieces consisted of four makes of particle board. Size of samples was 3 in. wide, ¾-in. thick and placed on 12-in. centers, followed by loading each with 25 lb. test loads for 12 weeks. It was found that the largest sag occurred in the first seven days in all cases, and at a decreasing rate thereafter. Boards which were veneered on both sides with 0.7 mm Sapele were twice as stiff and 1/3 to ½ more resistant to creep than unveneered boards of the same make.

Recovery of the particle board was found to be rapid in the first four days following load removal, then decreasing in rate. The samples having the largest deflection or creep also had the largest recovery, but no sample completely recovered within 20 weeks. The largest remaining permanent set, however, was hardly perceptible over the whole span.

From this investigation, it appeared that single-layer, unveneered particle boards were not suitable for shelving unless more support was used than is necessary for solid wood. It is felt that there is a possibility of veneered particle board being used satisfactorily for medium-duty shelving.

Table 1.—CHARACTERISTICS OF MARKETABLE FURNITURE PARTICLE BOARDS FROM CONIFEROUS WOOD*

Plant	Type of Wood	Board Thickness Inches	(Sp. Gr.) Raw Weight g/cc	Bending Strength psi Average	Tensile Strength psi Average	Swelling % In Water	Specific Nail Holding Perpendicular To Surface psi
1	Spruce	¾	.58	2280	1280	21	356
2	Spruce	¾	.56	2350	1422	15	413
3	Spruce	¾	.56	1850	854	12	270
4	Pine	¾	.63	2200	1138	24	427

*Properties of particle board produced in Germany considered to be suitable for high quality furniture panels (4).

Weyroc, a board produced in Britain, is recommended for use in shelving according to Table 2, which illustrates, for their ¾-in. board, maximum support centers. This information applies specifically to the Weyroc board. Boards made by other companies, with different physical properties, would of course be subject to individual consideration.

Screw-Holding Ability

Screw-holding ability, particularly for particle boards in the density range 0.55–0.80, is usually less than that of lumber such as poplar. To obtain a relative picture of screw-holding ability is difficult, particularly since no standards exist for testing this property.

In most cases the test results list the size and depth of penetration of the screw as well as the pilot hole size used. In boards produced by the multi-platen process, screw-withdrawal perpendicular to the surface requires, in some instances, twice the force that is required for withdrawal from the edge of the board. Screw-holding ability is, to a large extent, controlled by board density, and to a lesser extent by resin content, chip orientation, particle size and shape, etc.

It has been found that screw-holding ability is greatly enhanced by the application of resin to the pilot hole prior to insertion of the screw. In some cases, where resin is placed in the pilot-hole, withdrawal may require 100 per cent more force. There is evidently a maximum size for the pilot hole, since some tests have shown that a reduction in pilot-hole size will aid screw-holding ability. Wissing (7) suggests that the optimum pilot-hole size should be approximately 75 per cent the diameter of the threaded section of the screw.

Where still additional strength is required than is obtainable otherwise, especially when screwing into the edge of some boards, it has been suggested that larger and longer screws may increase the withdrawal force required (7). Another possible solution may be effected by edging with solid lumber.

Machinability

To the furniture manufacturer, machinability is an important consideration. Can it be sawn, routed, drilled, planed, and sanded? If so, do the various operations measure up in quality to a reasonably good solid core stock? For the most part, the answer is an emphatic yes.

It must be remembered that particle board is a wood substance and therefore may be worked with the same machine and hand tools that are in use in the wood industry today. One must, however, take into account the presence of the synthetic resin binder and its possible effects on the tools. It has been found that the cutting edges of machine tools will become dull more rapidly than with natural wood. The necessity for maintaining sharp edges in machining cannot be overemphasized for the furniture manufacturer, for this is necessary in order to obtain good surfaces and to hold close dimensional tolerances.

An important economic consideration that cannot be overlooked is that power consumption of a tool with dull edges is roughly double that of one whose cutting edges are kept sharp. For these reasons, more and more manufacturers and users of particle

Table 2.—RECOMMENDED SUPPORT CENTERS FOR SHELF CONSTRUCTION, ¾-INCH WEYROC (6)

Shelf Width in inches	Maximum distances in inches between supports for the loads shown* 10-lbs.	20-lbs.	30-lbs.	40-lbs.	50-lbs.	60-lbs.	70-lbs.	80-lbs.	90-lbs.	100-lbs.	110-lbs.	120-lbs.
3	20½	14½	12	10	9	8						
6	29	20	16½	14½	13	11½	11					
9	35	24½	20	18	16	14½	13½	12½				
12	41½	29	24	20	18	16½	15½	14½	13½	13	12	
15	46	32	26½	23	20	18½	17	16	15	14½	13½	13
18	50	36	29	24	22½	20	19	17½	16½	16	15½	14½

*Tables are based on a deflection not greater than 1/360 x span, and distributed load. Multiply spans by 0.8 for concentrated loads.

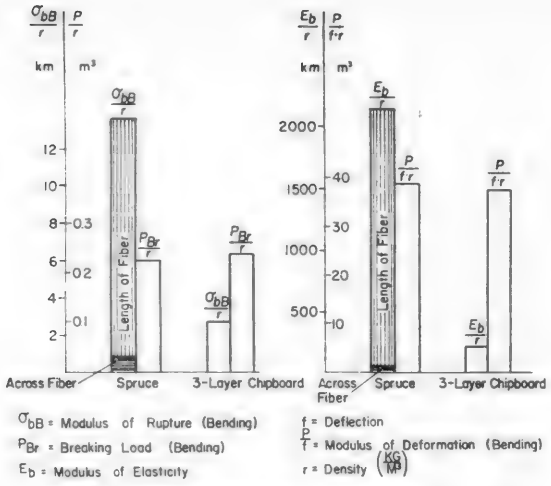

Fig. 2.—Bending properties of spruce and 3-layer (sandwich) type particle board (3).

board are turning to hard metal-tipped cutting edges for machine tools. The Weyroc Co. lists the approximate interval between sharpening of saws as 15,000 ft. for carbide-tipped saws as against 3,000 ft. for steel plate saws (6).

With respect to sawing, other recommendations of the Weyroc Co. are as follows:

1. A Riving knife should be used to avoid pinching at the back of the saw.

2. The depth of the saw protruding out of saw bench should be ½ in. greater than the thickness of the material being cut. This avoids side slap and cutting by the back of the saw.

3. In general, the cutting should be done with a fine-toothed saw running at high speed.

With regard to profiling, routing, and grooving, high cutting speeds are necessary to produce clean work. Feed should be slow enough so that individual chips are not torn out of the mass.

Drilling is accomplished with as much ease as with natural wood. The Bartrev organization (5) has found that, "for coarse chipboards, twisted augers are more suitable. When large holes have to be bored it is better to use augers with saw teeth, but for cut edges the holes are best made with a pneumatic drill or hand borer. Here again, the easiest way for clean cutting is to use high speeds. The drilling of slots or grooves must be done from the center to both sides, which is the converse of the procedure normally adopted with natural wood."

Conclusions

Lumber corestock is, in general, superior to particle board in such physical properties as bending (Fig. 2) and tensile strength, screwholding ability, machinability, and density (insofar as lower specific gravity is concerned). Particle board, on the other hand, rates higher than lumber in hardness, dimensional stability control, low thermal conductivity, and freedom from defects throughout the piece.

A comparison of the two furniture core materials on the basis of the above factors, however, is not sufficient for choosing either one or the other for a particular application. Rather, a decision of this nature should result from a much more comprehensive analysis. Particle board has presently attained a position in the furniture industry so prominent that it cannot be ignored, and its use is increasing so rapidly that it appears the future development and continued progress of the product will not be halted.

This places a responsibility on the furniture manufacturer. He must now investigate particle board in relation to its potential application in his products because of the economic consequences, if for no other reasons. A single comparative look at particle board's relative merits should be replaced by a careful analysis of all the factors involved, including a survey of markets and economic studies.

The use of particle board in furniture manufacture need not result in a lowering of the product quality, if full cognizance of its properties is taken and the board is intelligently applied. Considering the cost differential between lumber core and particle board, it is wasteful to use the former in cases where the latter accomplishes the same end by more complete utilization of its potential. Since the qualities in particle board can be varied to meet a wide range of end uses, this allows the furniture producer considerable latitude in his choice. There are numerous applications in the furniture industry where particle boards cannot perform the task as well as lumber core, all factors considered. The point here is that the only means of determining which is the most satisfactory in a particular situation is a complete analysis of all pertinent factors.

To date, laboratory test results dealing with chipboard must be interpreted with a great deal of care, as the results from different sources are often contradictory. To say that a given board possesses this or that quality does not mean too much. It remains to obtain a set of accepted standards for particle board, after which the furniture manufacturer will be in a better position to decide for himself whether lumber core or particle board is the best choice in a given application.

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Discussion

Frank Campbell (Wynnewood Products): What is the average thickness in use?

Mr. Johnson: The average thickness is ¾ inch. The board is manufactured ⅝ to ⅞ inches but is usually planed or sanded.

Mr. Campbell: Is a particular bonding adhesive preferred, ie., urea vs. phenol?

Mr. Johnson: Urea-formaldehyde resin is usually preferred because it is the cheapest, sets quickly with the application of heat, and produces a satisfactory board when the product is not subjected to excessive heat or severe moisture conditions.

Mr. Campbell: Do manufacturers accept 4 x 8 sizes or do they prefer cut sizes?

Mr. Johnson: Most manufacturers accept 4 x 8-foot size panels but furniture manufacturers prefer cut-to-size panels. Several furniture manufacturers

have reported that 66-inch x 110-inch or 66 x 130-inch presses produce the best cuttings for their sizes. The plastic top dinette and cabinet trade report that multiples of 30-inch widths are best for them.

James Cummings (Dow Chemical Co.): Just how big is this particle board business? What is the annual production?

R. Louis (Bramco Corp.): Reliable statistics do not exist as the Dept. of Commerce has not yet set up a classification. It is my opinion that the amount of particle board produced and sold last year (1955) was approximately 80 million sq. ft. (on a ¾-inch basis.)

Mr. Cummings: Is it necessary to put a veneer on chipcore?

Mr. Johnson: It is necessary to put a veneer on chipcore if stiffness is an important property desired or to obtain proper appearance. Many boards are manufactured with flake surfaces for use without veneering.

Mr. Cummings: Is there a place in particle board products for a low cost functional veneer or overlay?

Mr. Johnson: Yes. It can be used for shelving, painted cabinets, doors and possibly sheathing and wallboard.

Ben S. Bryant (University of Washington): Are physical test data like "E" (modulus) being presented by the manufacturers?

Mr. Johnson: Most manufacturers present the test data for their boards but there have been no standard test procedures or values established up to this time.

J. P. Dowd (West Virginia Pulp and Paper): What are the comparative cost factors of producing particle board as compared to hardboard using the same type of chips?

Mr. Johnson: A thin board, ⅛ inch to ¼ inch, can be produced most economically by the wet hardboard process and a thick board most economically by the dry particle board process. The equipment investment is less for the particle board process.

Mr. Dowd: Where are the areas where these two (particle board and hardboard) compete?

Mr. Johnson: The two types of boards compete for such markets as wallboard, back panels of furniture, and corestock for ⅜-inch plywood.

J. R. Stillinger (Cascade Plywood Corp.): What is the moisture content desired by a manufacturer of furniture?

Mr. Johnson: Most furniture manufacturers want particle board to be from 5 to 8 per cent moisture content. The lower ranges are desired for core boards.

Mr. Stillinger: Is a moisture content gradient in core material a significant factor?

Mr. Johnson: Yes, the moisture content gradient is extremely important for a core board. At the time of veneering, the core board must be relatively uniform in moisture content to prevent warping and blistering.

Richard Campbell (National Gypsum): Assuming the perfect felter or dry forming machine has not yet been developed, which imperfection would be more acceptable to the furniture industry: wedge-shaped as far as caliper is concerned, or uneven density with no caliper variation resulting from restricting press closure by stop bars.

Mr. Johnson: The furniture industry prefers a homogeneous core board of uniform density. Such a board can be planed or sanded to obtain uniform thickness.

W. K. Conard (Collier Co.): Are any chipboard plants now using the whole tree instead of waste material as a raw material?

Mr. Johnson: Yes, a number of plants in Europe use low grade forest trees and some factories in the United States use cordwood as part of their raw material.

Effect of Cyclic Humidification on Dimensional Stability of Commercial Hardboard[1]

R. A. CURRIER

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To determine the effect of cycling relative humidity conditions on dimensional stability of hardboard, standard ⅛- and ¼-inch boards manufactured by seven different processes were subjected to 12 cycles of 30–90–30 per cent relative humidity. Weight, thickness, and linear changes were measured after conditioning at 30 per cent relative humidity and families of typical curves depicting the changes were constructed.

RELATIVELY LITTLE INFORMATION is available concerning the effect of humidity changes on the properties of moisture absorption and desorption, linear expansion and contraction, and thickness swelling and shrinking in commercial hardboard produced in the United States. These are important properties when hardboard is used under conditions where humidity variations are present.

Humidity changes may be the result of natural weather conditions, or they may be produced artificially in enclosed buildings. The results of day-to-day or seasonal fluctuations in humidity on the shrinking and swelling properties of wood are well known, and usually are taken into consideration when wood is used under such conditions. Past experience has shown that hardboard usually does not behave as wood does; consequently, available data on the effect of humidity exposure on wood are not directly applicable to hardboard.

With the large increase in the volume of hardboard produced during the past few years, many new uses for this material have been discovered. In some instances, severe humidity variations are encountered. If the behavior of hardboard under such conditions could be predicted, the material could be used more advantageously and perhaps might be tailored especially for severe use conditions. This study was part of a larger research program at the Oregon Forest Products Laboratory designed to evaluate the strength and related properties of hardboard.

Previous work and related studies: The only published information pertaining to the effect of repeated cyclic humidification on the dimen-

[1] Presented at meeting of FPRS Pacific Northwest Section Feb. 6–7, 1956, in Longview, Wash.

The Author: R. A. Currier holds B. S. from U. of Massachusetts, M. S. from State University of New York College of Forestry. A FPRS member, he has been wood technologist at the Oregon laboratory since 1952 and is now in charge of the manufactured products department.

sional stability of hardboard was from European sources. In Sweden, N. J. Ögland (4, 5)[2] has completed a considerable amount of work on the swelling and shrinking properties of Swedish hardboard. Moisture conditions included both humidification and water soaking. Hardboard was subjected to nine repeated cycles of 30–90–30 per cent relative humidity, and changes in thickness and length were observed. Ögland found an increase in thickness and a decrease in length, with the greatest change occurring between the first and second cycle. Subsequent changes in thickness were negligible, but the boards continued to decrease in length through nine cycles.

Schwartz and Baird (6) oven-dried experimental hardboard, then exposed it to 97 per cent relative humidity followed by redrying. At the completion of this single cycle and based on the original oven-dry measurements, increases were noted in the weight and thickness while the length decreased.

Previous work at the Oregon Forest Products Laboratory (7) included a report on the dimensional stability of hardboard subjected to a single change in relative humidity from 30 to 90 per cent. Additional work is in progress comparing the dimensional changes caused by water soaking for 24 hours with changes resulting from long-time exposure to 90 per cent relative humidity.

The British Standards Institution also has investigated the effect of relative humidity on the dimensional properties of hardboard (1). A nonmandatory clause in British Standards 1142:1953 outlined a test method for measuring dimensional changes when test boards are exposed to a change in relative humidity from 33 to 90 per cent.

In the United States, the Hardboard Association (2) has a tentative test procedure to measure lineal dimensional variations in hardboard with a change in relative humidity. Without previous oven drying, boards are subjected to a cycle of 30–90–30 per cent relative humidity, all at 90° F. Linear changes are determined at the end of each relative humidity condition.

A recent research paper completed by Lorey and Libby (3) on methods of dimensionally stabilizing paper discusses a large part of the published literature concerned with the dimensional stability of paper and papermaking fibers.

Objective: The major objective of the investigation was to determine the weight change, thickness swelling and shrinking, and linear expansion and contraction for 14 different types of standard (untreated) hardboard during 12 repeated cycles of 30–90–30 per cent relative humidity.

[2] Numbers in parentheses refer to literature cited.

Experimental Procedure

Scope: Standard 1/8- and 1/4-inch boards of 7 different companies were included in the investigation, making a total of 14 different board types. Each board type was represented by five 3- by 12-inch specimens, for a total of 70 specimens. The products of each company represented a different process of hardboard manufacture.

Design: Since little was known about the results of cyclic humidification on the dimensional stability of hardboard, the specimens were limited to the standard type of hardboard. Previous work completed at the Oregon Forest Products Laboratory (7) indicated that standard hardboard showed a higher rate of moisture pickup and subsequent dimensional change than did treated hardboard, when each was exposed to 90 per cent relative humidity. It was believed, therefore, that any important variations in dimensional properties of the hardboard would be detected more easily if standard board were used.

The humidification conditions of 90 per cent relative humidity at 80° F. and the dehumidification conditions of 30 per cent relative humidity at 100° F. were probably more severe than those ordinarily encountered where hardboard is used as a construction material. In order to magnify the amount of dimensional changes that would occur during experimental procedures, the wide variation in humidity appeared justified. Once the trends of these extreme dimensional changes were known, the effect of relative humidity changes on the dimensional properties of hardboard could be determined more easily for conditions less severe.

Variations in relative humidity and temperature in the large conditioning rooms used in the study were considerably greater than those occurring in saturated salt solutions which Ögland (4, 5) used for humidity control. However, it was believed that if reasonable care were exercised, use of the conditioning rooms would not prevent the discovery of important dimensional changes in the hardboard.

Each of the 14 types of hardboard were represented by five 4- by 4-foot sheets collected at random. These sheets were cut into 12-inch squares numbered in a uniform pattern from 1 through 16. With the aid of a table of random numbers, 1 square from each group of 16 was chosen for specimen preparation. One 3- by 12-inch specimen was cut from the square with the long axis perpendicular to the original machine direction of the sheet. Thus, for each board type, there was one specimen for each of the five 4- by 4-foot sheets.

Care was used in cutting the test specimens, for it was known from previous experience that straight, smooth edges were necessary in order to measure length changes with accuracy.

Testing procedure: All 70 specimens initially were conditioned for about three months in a room with an atmosphere of 30 per cent relative humidity at 100° F. Periodic weight checks indicated that an equilibrium moisture content condition had been reached.

To remove any possible differences in drying rate caused by position of the specimens within the conditioning room, they were mixed thoroughly at established time intervals. The specimens were placed in single layers on three shelves, using narrow 1/4-inch hardboard stickers as a base.

When the specimens had reached equilibrium under the above conditions, the following data were obtained for each specimen:

1. Weight to the nearest 0.1 gram.
2. Thickness to the nearest 0.001 inch at a point near the geometric center of the specimen, measured with the aid of a plane table. The reference point was marked in order that subsequent thickness measurements would be taken at the same place.
3. Length of the long axis of the specimen to the nearest 0.001 inch, using a Dial Gauge Comparator.[3]

Initial measurements were the bases for computing all subsequent percentage changes in weight, thickness, and length caused by exposure to cyclic relative humidity.

After the initial measurements were completed, the specimens were mixed thoroughly and placed in a room with an atmosphere of 90 per cent relative humidity at a temperature of 80° F. The duration of exposure to this high relative humidity was 168 hours, or 1 week. Weight, thickness, and length measurements for each specimen were taken after 2, 6, 12, 24, 48, 96, and 168 hours' exposure. The specimens then were returned to 30 per cent relative humidity at 100° F. for dehumidification, and the same measurement procedure used as for the high relative humidity phase of the cyclic treatment.

[3] American Society for Testing Materials D 1037–52T.

Thus, a complete cycle consisted of 168 hours at 90 per cent relative humidity followed by 168 hours at 30 per cent relative humidity. The specimens were subjected to a total of 12 complete cycles lasting 24 weeks. However, measurements were taken only during cycles 1, 2, 3, 6, and 12.

As soon as data were obtained during cycling, the percentage changes in weight, thickness, and linear dimensions were calculated, based on the initial measurements at 30 per cent relative humidity. Rough curves consisting of the percentage change plotted over exposure time were drawn as each cycle progressed. These curves served as guides for determining probable reactions in the boards, and resulted in detailed measurements during certain cycles while, in others, no measurements were taken. Where a particular cycle was run without measurement, the established mixing and repiling procedures were followed.

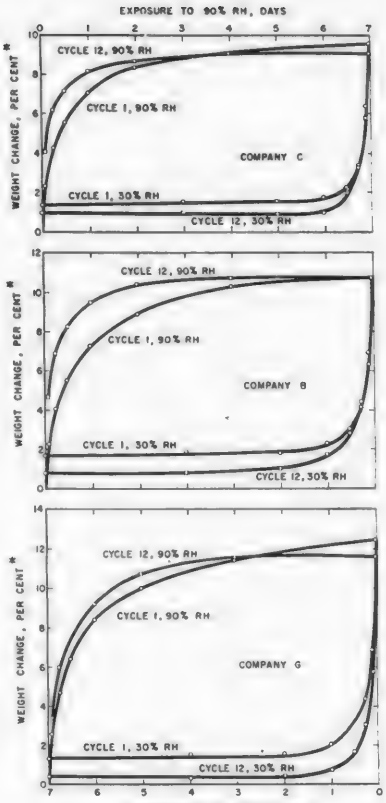
At the end of the twelfth cycle, the oven-dry weight of the specimens was determined as a base for calculating moisture contents.

Results and Discussion

With 14 different types of standard hardboard represented in the test procedure, graphical presentation of weight and dimensional changes for all types would have become too lengthy. The hardboard types were divided, therefore, into the two thickness classes, 1/8- and 1/4-inch, and three hardboard types in each thickness class were chosen for graphical presentation of each of the three properties investigated (weight, thickness, and linear change). The particular board types were selected to show the differences in physical properties usually encountered in hardboard produced by different manufacturers.

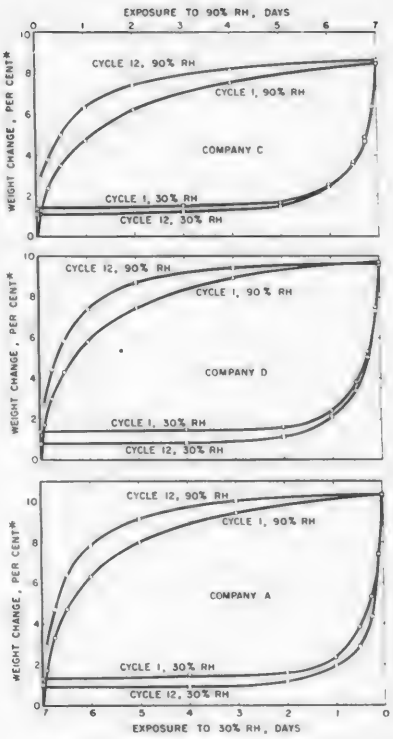
To show the effect of cycling, data for only the first and twelfth cycles were plotted in Figs. 1 through 6. Curves for the second, third, and sixth cycles usually fell between curves for the first and twelfth cycles, and thus led to a congested family of curves when all were plotted. Conclusions were based on relative changes in position of the curves for cycle 12 compared with cycle 1. Comparisons were made for both the humidification and dehumidification phases of the relative humidity cycle.

Mimeographed copies of complete dimensional property data for all types of hardboard investigated are available upon request from the Oregon Forest Products Laboratory. In addition to dimensional properties, percentage moisture contents based on oven-dry weight are included.



* Based on initial weight at 30 per cent relative humidity.

Fig. 1.—Rate of weight change during exposure to the first and twelfth cycles of 30–90–30 per cent relative humidity; standard 1/8-inch hardboard from three companies.



* Based on initial weight at 30 per cent relative humidity.

Fig. 2.—Rate of weight change during exposure to the first and twelfth cycles of 30–90–30 per cent relative humidity; standard 1/4-inch hardboard from three companies.

Weight change: Weight changes for 1/8- and 1/4-inch hardboard are presented in Figs. 1 and 2, respectively. Inadvertently, the initial measurements at the start of cycle 12 were not obtained.

An increase in rate of weight change occurred between the first and twelfth cycles during the early stages of humidification. In most boards, these increases were quite small and reached their maximum in the second or third day of exposure to high relative humidity. At the completion of the twelfth humidification period of 7 days, a number of the 1/8-inch boards had picked up slightly less moisture than in the first period. The majority of the 1/4-inch boards at the end of the twelfth cycle had weight changes about equal to those found at the end of the first cycle.

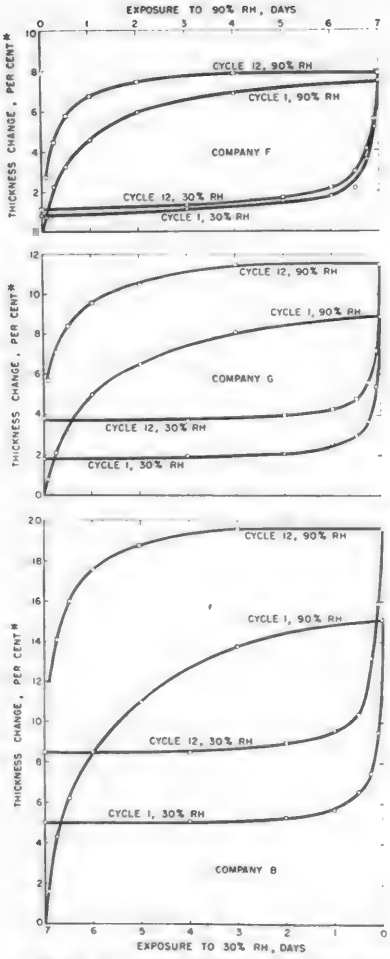
All types of hardboard dried to lower weights in cycle 12 than were reached at the end of cycle 1. Only slight changes in weight occurred in cycles 1 and 12 after the second day of dehumidification.

The general shapes of the curves for 1/8- and 1/4-inch boards are similar. As would be expected, the rate of change in weight was noticeably less in the thicker material, especially during the first few hours of either humidification or dehumidification. This comparison was true during all cycles of exposure.

Thickness change: Typical rates of thickness change for 1/8- and 1/4-inch hardboard are presented graphically in Figs. 3 and 4, respectively. Every type of hardboard exhibited greater thickness at any given time in the cycling when cycle 12 was compared with cycle 1. Some increase in thickness during exposure to high humidity should be expected because of the slight increases in percentage weight change previously discussed. However, in certain boards, the increase in thickness was much greater than normally would be attributed to moisture absorption.

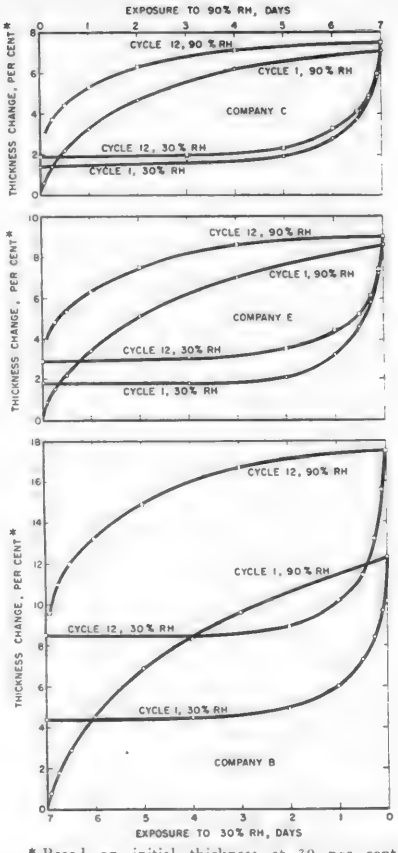
During the low-humidity portion of the cycle, the thickness of all boards increased between cycle 1 and 12 while the amount of moisture in the boards decreased slightly, as evidenced by lower weight at the end of cycle 12.

A comparison of the two thickness classes (1/8- and 1/4-inch) indicates that the thicker boards generally showed a lower rate of thickness change, especially during the first day of exposure to high or low relative humidity. The usual wide variation in property values encountered in testing the products of different manufacturers was evident in thickness change.



* Based on initial thickness at 30 per cent relative humidity.

Fig. 3.—Rate of thickness change during exposure to the first and twelfth cycles of 30–90–30 per cent relative humidity; standard ⅛-inch hardboard from three companies.



* Based on initial thickness at 30 per cent relative humidity.

Fig. 4.—Rate of thickness change during exposure to first and twelfth cycles of 30–90–30 per cent relative humidity; standard ¼-inch hardboard from three companies.

Linear change: The rate of linear change for three types of ⅛- and ¼-inch hardboard are shown in Figs. 5 and 6, respectively. For the property of linear change, it was found that the products of six of the seven manufacturers showed shrinkage in length at any given time in the cycling when cycle 12 was compared with cycle 1. The direction of movement was opposite to that found for thickness change, where progressive swelling was evidenced during successive cycles.

Indications of the trend toward shrinkage in length were ascertained during the dehumidification portion of the first cycle. The boards of six manufacturers showed shrinkage below the initial length measured after conditioning at 30 per cent relative humidity. The shrinkage increased with each new cycle up through cycle 6; very little difference was noted between the amount of shrinkage in cycle 6 and cycle 12.

As was found for thickness change, it appeared that linear dimensions did not change directly with the amount of moisture change occurring in the boards. During the humidification phases of the cycles, weight generally increased with the number of exposure cycles while linear dimensions decreased for the products of 6 companies. In the dehumidification phases of the cycles, both weight and linear dimensions progressively decreased. In contrast to the length, however, the weight never fell below that measured before cycling.

In general, the ¼-inch boards showed a lower rate of linear change during the early stages of humidification than did the ⅛-inch boards. This relationship was noticeable also during the first few hours of exposure to low relative humidity.

An anomalous relationship was found for the products of Company B in linear change. At any stage of humidification and dehumidification, there was a greater increase in length during cycle 12 than during cycle 1, with the greatest difference occurring during exposure to high relative humidity. The magnitude of expansion was much greater than that normally encountered in hardboard. When exposed to low relative humidity in cycling, the boards of Company B were the only ones that did not shrink below the original length measured after conditioning at 30 per cent relative humidity.

Comparison of weight, thickness, and linear change: Comparisons of percentage changes in weight, thickness, and linear dimensions at 5 different cycles of 30–90–30 per cent relative humidity for ⅛- and ¼-inch hardboard are shown in Figs. 7 and 8, respectively. The products of two manufacturers are shown. Dimensional changes in the products of Company D may be said to represent an average reaction to cyclic changes in relative humidity, while those of Company B represent an anomalous reaction.

The plotted points show the average percentage change after 168 hours' exposure to either 90 or 30 per cent relative humidity. Inadvertently, the initial measurements at the start of cycle 6 and cycle 12 were not obtained.

General trends in successive cycles of relative humidity are quite apparent from an examination of Figs. 7 and 8. The variation between cycles in percentage weight change at the end points was relatively minor for both companies, indicating that the amount of moisture gained and lost remained practically constant.

In percentage change from the original thickness, both the ⅛- and ¼-inch products of Company D increased slightly after repeated exposure to high and low relative humidity. A similar comparison for Company B shows a substantial thickness increase.

The great difference in percentage linear change between the boards of Company B and all other types may be seen in Figs. 7 and 8. The products of Company D progressively decreased in length at the ends of both phases of the relative humidity cycles. At 30 per cent relative humidity this decrease contracted the boards below their original length after conditioning at 30 per cent relative humidity. This shrinkage occurred even in the first cycle. In contrast, the boards of Company B increased in length after cyclic relative humidity exposure. Although the performance was erratic, the greater range of linear movement and its continuing expansion was quite evident.

Conclusions

Based on the data obtained from subjecting 14 different types of standard hardboard to 12 cycles of 30–90–30 per cent relative humidity, the following conclusions appeared justified when cycle 12 was compared to cycle 1:

1. As evidenced by weight change, the amount of moisture added during humidification in most board types remained about the same during successive cycles. The moisture remaining after dehumidification was lowered by successive cycling.
2. The thickness of all boards at any given point in the cycling increased from cycle 1 to cycle 12.
3. In 12 of the 14 board types, the length at any given point in the cycle decreased during successive cycles. The remaining 2 types (produced by the same manufacturer) increased in length during successive cycles.
4. In general, the change in weight, thickness, and length per unit of time was lower for ¼-inch boards than for ⅛-inch boards.

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Discussion

Q. Was there a noticeable difference between the three types of boards?

A. No.

Q. Is there any explanation as to why linear dimensions decrease with humidification?

A. The material is semi-elastic. An increase in thickness probably results in a decrease in length. European workers start with an oven-dry board.

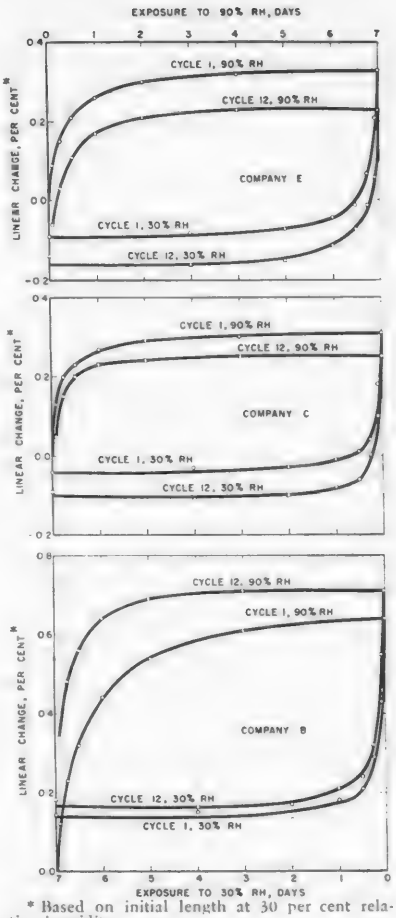
Q. Did the one board which increased in both length and thickness decrease in density?

A. It was above average in density and did decrease.

Q. Did you observe a "set" during pressing that affects dimensional changes?

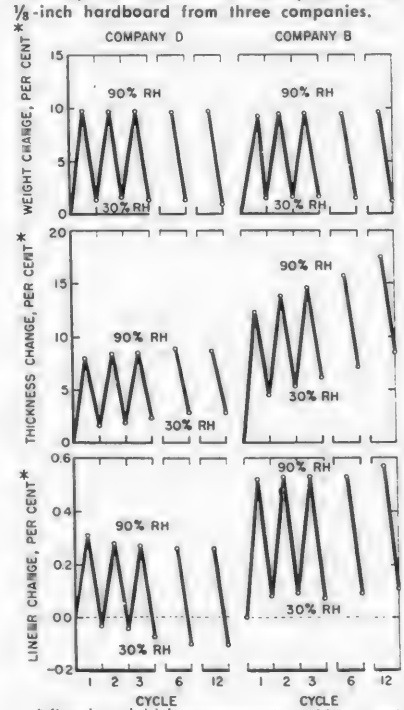
A. Yes.

Q. Were any tempered boards used?



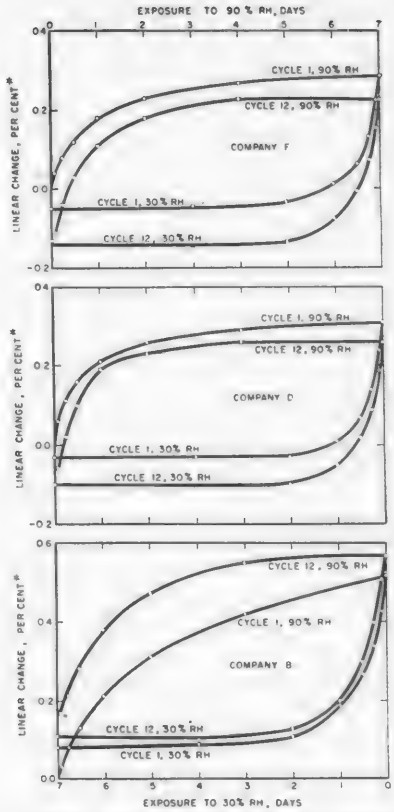
* Based on initial length at 30 per cent relative humidity.

Fig. 5.—Rate of linear change during exposure to the first and twelfth cycles of 30–90–30 per cent relative humidity; standard ⅛-inch hardboard from three companies.



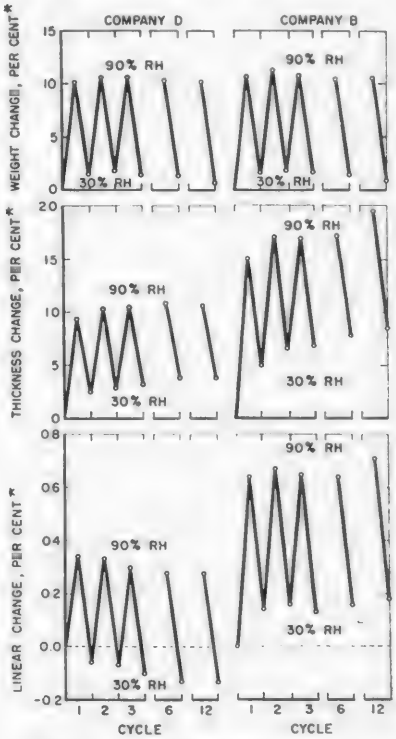
* Based on initial measurements at 30 per cent relative humidity.

Fig. 8.—Weight, thickness, and linear change during exposure to several cycles of 30–90–30 per cent relative humidity; standard ¼-inch hardboard from two companies.



* Based on initial length at 30 per cent relative humidity.

Fig. 6.—Rate of linear change during exposure to the first and twelfth cycles of 30–90–30 per cent relative humidity; standard ¼-inch hardboard from three companies.



* Based on initial measurements at 30 per cent relative humidity.

Fig. 7.—Weight, thickness, and linear change during exposure to several cycles of 30–90–30 per cent relative humidity; standard ⅛-inch hardboard from two companies.

A. All were standard, untreated boards. These are more sensitive to changes in atmospheric conditions.

Q. How were the boards preconditioned for the test?

A. In standard humidification rooms.

Q. Was an artificial humidity chosen and maintained throughout the test?

A. No. Some variation occurred during the test. Results averaged out.

Q. Was there any "corking"? (Sudden expansion of bark particles in the boards).

A. No boards with bark were used.

Q. What are the limits of included bark?

A. 17–18 per cent in some boards. The amount is not standardized.

Q. Are the differences due to method of manufacture or to raw materials?

A. These were not tested. The problem is complex, involving many variables often not known to the research worker. These variables include length of time logs were stored, and temperature, time, pressure, etc., in manufacture.

Quality Control in the Production of Laminated Timbers[1]

M. J. RHUDE

Chief Engineer, Unit Structures, Inc., Peshtigo, Wis.

Discusses all categories in which quality control operates in laminated timber fabrication. These include: surveillance of quality throughout all phases of manufacture, sampling the product for testing and acceptance or rejection, establishing proper production procedures and product specifications, training production personnel in quality practices, liaison between production and engineering, analysis of service reports, and action as a trouble-shooting service.

GLUED LAMINATED TIMBER is an assembly made by bonding layers of lumber together with adhesive so that the grain direction of all laminations is essentially parallel. Quality control in the production of these timbers includes all procedures used by a laminator to furnish a quality product. To be called a quality product, it must conform to good practice and job specifications. It must satisfy the customer and make a profit for the laminator.

Quality control is not merely an inspection and testing program. Its function is not to assemble a lot of data for the files. Rather, it must gather data which can be used in the detection and correction of poor quality.

The real secret of success of a quality control department lies in defect prevention, by feeding information back into the production department as soon as possible, so that faulty production may be stopped.

Why have a quality control department? Pressures for maintaining and increasing the quality of products and the problems caused by ever-increasing production have brought quality control to the glued laminated timber industry.

Specifically, there has been a need for fabrication of members suitable to meet or exceed competition. The quality control department came into existence because of customer complaints and the requirement that repair and waste be eliminated in the process of making an acceptable product.

The department acts for management to carry out the company quality policy. In a single-plant company, both production and quality control are frequently responsible to a manufacturing manager. In a company having a multiple-plant arrangement, it is usual for quality control to report to an individual not responsible for establishing and meeting production quotas. This may be the vice-president in charge of engineering or chief engineer, as in our organization. The department is considered so important as to be given a status equal to that of design or research and development.

Quality control data is collected by an inspector or laboratory technician. These people report to a chief inspector, who receives his assignments from the chief engineer.

Personnel should have no authority or responsibility in production matters. It is, however, their job to sell the idea of quality through recommendations on quality practices that can ultimately be carried out by production.

A perfect relationship is one where production requests the services of quality control personnel to help their own ideas on quality practices to become final. This relationship is not difficult to obtain if quality control is tied in with an incentive program or inspectors are selected properly from the ranks of production. Practical persons with statistical knowledge are required who have a desire to learn production and engineering. Inspectors must read and understand structural shop drawings. They would be of little value in assuring management that the product, ready for shipment, fully meets specifications, unless they had this ability.

These persons should have a working knowledge of the properties and performance of wood with respect to its end use. Knowledge of seasoning effects, construction tolerances, and tools and equipment used should be a basic requirement for such people. Supervisory personnel should have knowledge of the gluing properties of the various species, glues to be used, and procedures and techniques of gluing similar to those set forth in U.S. Forest Products Laboratory Technical Bulletin No. 1069.

Quality control must keep paramount its purpose of encouraging in others a habit for quality. "Habit is a cable; we weave a thread of it every day, and soon we cannot break it," stated the noted educator, Horace Mann.

The customer, when speaking of a product, may say: "The company is good and I will be a repeat customer for its product". Who is that man talking about when he refers to the company? He speaks about a person or group of persons who are causing the product to be a reality. Some responsible individual or group of individuals performs an effort for which he will be blamed and made to pay a penalty if the work is wrong or given credit if the work is right. Someone once said: "In all departments of activity to have one thing to do, and then to do it, is the secret of success." Quality

[1] Presented at Session VI, Glues and Gluing, FPRS Tenth National Meeting, June 4–7, 1956, in Asheville, N. C.

The Author: M. J. Rhude holds B. S. and M. S. degrees from the U. of Wisconsin. He was associated with the University and the Forest Products Laboratory before joining his present employer in 1951.

Fig. 1.—Checking kiln-dried southern pine lumber at the start of the laminating process.

Fig. 2.—Laying out full-sized pattern for a laminated arch.

Fig. 3.—Layout of boards prior to edge- and end-gluing operations.

control has been established for one purpose. That purpose is to prevent anything passing into the hands of the customer which will prevent him from saying: "The company is good and I will be a repeat customer for its product".

Quality Control Functions

Quality control functions in the following categories of glued laminated timber production:

1. Surveillance of quality throughout all phases of fabrication—from receipt of raw materials to shipment of the finished product.
2. Sampling of the completed product for testing and acceptance or rejection.
3. Assistance in the establishment of proper production procedures and product specifications.
4. Assistance in the training of production personnel in quality practices.
5. Liaison between production and engineering design and drafting.
6. Analysis of service reports.
7. Action as a trouble-shooting service.

The first two functions lie so closely together that they will be combined in considering the role of quality control in the fabrication process.

1 & 2. Surveillance of quality during all phases of fabrication and testing of the completed product: The industry Inspection Manual (1)[2] reads as follows, "Since the quality of structural glued laminated lumber depends on materials and operations which cannot be fully examined in the completed product, it is expedient to inspect the work during the laminating process."

Nine separate areas for observation exist in the fabrication process:

[2] Numbers in parentheses refer to literature cited.

a. Receipt and storage of raw materials: All materials—lumber, glue, connection steel, finish, and protection items—must conform to the purchase specifications.

Laminating lumber must be in the range of 8–14 per cent m.c., with every effort made to approximate the moisture content the laminated member will attain in service. Moisture meters and the oven test assure proper moisture contents of lumber at this and at two other stages of the fabrication process.

The grade, thickness, and width of lumber, and the appearance of board edges with respect to wane, stain, pitch, knots, and knot holes, must meet definite requirements or come within set tolerances.

Samples of glue lots are tested under plant conditions prior to acceptance for production use.

When found acceptable, these same materials are checked for storage method. Laminating lumber must be maintained in the condition in which it was received. Glue must be stored within certain relative humidity and temperature limits. Kiln-dried southern pine (2), is the wood used almost exclusively in our laminating operations. It is shown in Fig. 1 being received and checked at the start of the laminating process.

b. Pattern construction: A full-sized pattern (Fig. 2) is necessary for form setup and for the finishing of members in accordance with shop drawing requirements. Few checks are more important than those devised here for assurance that members made from patterns will fit field conditions.

The proper placement of various grades of lumber in the laminated member is indicated by the patternmaker at this time. Combinations of grades have been assigned definite stress values. Designers must have assurance that the proper grade is situated in the completed member where it was meant to be.

c. Layout of laminations: In accordance with the design department and patternmaker instructions, boards are now selected from inventory in such a manner that completed laminations are correct with reference to size, structural grade, and appearance characteristics.

Fig. 3 presents a typical layout of boards prior to the edge- and end-gluing operations. Commercial grades of lumber can be and are used in almost all cases for glued laminated timbers. Two or more grades within the same timber are common. The standard finished width for laminated timbers is in general one inch less than the nominal width of commercial lumber. For example, an 8-inch board, actually 7½ inches in width, makes a standard 7-inch laminated member. The molded depth of members should, whenever possible, be an even multiple of ¾ or 1⅝-inch laminations. Actually, this permissible thickness must vary with the radius of curvature of the member. Greatest economy will result if these maximum finished thicknesses, ¾ and 1⅝-inches, can be utilized from nominal 1- and 2-inch lumber.

Greater controls are frequently necessary on both equipment and procedures if such industry standards have not been observed in the design of the timbers.

d. Preparation of laminations by edge-gluing, end-gluing, and presurfacing: The precise mating of joining surfaces must exist after adhesive

and pressure are applied to a laminated assembly. The proper machining equipment is not enough. There must be continual maintenance of machine parts, particularly the cutting knives.

To minimize the effect of different shrinkage and swelling rates, flat grain should be edge-glued to flat grain and vertical grain to vertical grain.

Scarfs to be end-glued must have a smooth plane surface with no torn grain or splintered edges. Boards adjacent to a scarf joint must be matched with respect to grain and color for certain appearance grades.

Pre-surfacing must provide a gluing surface free from foreign materials and a smooth surface with no raised grain to interfere with intimate contacting of mating surfaces.

By this time, the lumber must not only be of the proper moisture content but it must be within the right temperature range. Extremes of temperature experienced at our Wisconsin and Arkansas plants bring this fact home to the quality control department.

At this machining stage of the fabricating process, preplugging of defects such as knots and knot holes on the board edges (Fig. 4) is accomplished to upgrade appearance values of the completed assembly.

Three appearance grades, Premium, Architectural, and Industrial (3), are in existence for the guidance of designers. Members may be specified consistent with the intended use of the structure so that appearance may be suitable at an appropriate price. Insertion of dutchmen in premium or architectural grades can be accomplished either before or during the finishing operation.

e. Glue preparation: Quality control instructions must adapt a glue manufacturer's recommendations to the particular laminating plant and product.

Selection of the proper adhesive for the job is only one of the steps for insuring a good glue bond. It must be mixed, stored, and spread in a manner

Fig. 4.—Preplugging of defects upgrades appearance value of completed assembly.

dependent upon the wood species being glued, gluing area temperature and relative humidity, and size of the assembly.

A wide range of gluing problems is presented in small boat framing fabrication compared to gluing arches for a huge area roof. This is illustrated by Figs. 5–A and 5–B.

Casein water-resistant glues are the rule rather than the exception in fabrication. Phenolic-resorcinol water-proof adhesives are increasing rapidly in usage.

f. Assembly gluing: One of the main places of concentration of quality control inspection is the assembly gluing phase of fabrication.

While it is true that most gluing troubles (5) are associated with time, temperature, and pressure, there are a minimum of 20 variables connected with gluing which determine the quality of the end product. One factor slightly off-color will not mean an unacceptable laminated member nor will strict adherence to only one or two of these factors mean that the product will be perfect. A definite curing temperature, regardless of curing time, will not correct a surfacing defect, a moisture content deficiency of the lumber, or a pressure inadequacy.

Quality control personnel should be vigilant in their search for answers to many gluing questions. Among the most important are:

1. Is the lumber moisture content proper?
2. Are gluing surfaces free from foreign materials?
3. Are mating surfaces pre-planed so as to properly receive glue and pressure?
4. What is the temperature of glue, lumber, and gluing area?
5. Is the glue mix and spread correct?
6. Are open and closed assembly times right for the particular combination of wood species, glue, and temperature?
7. Is pressure uniform, adequate, and applied in proper sequence?
8. Does application of pressure cause uniform squeeze-out of beads or threads of glue?
9. What is the glue line temperature?
10. Is proper clamping time observed?

Glue does not stick by some miraculous and strange doing. It does not work one day and not the next, when the same conditions exist and the same procedures have been employed both days.

Open and closed assembly times are important considerations when gluing a member containing 50 BM this moment and a few minutes later gluing one of 6,000 BM. Spread laminations clamped too soon can cause starved joints; those not clamped soon enough will have set glue before the application of pressure. Minimum assembly time has not been stressed adequately in available literature on gluing of laminated timbers.

Since equipment must be geared in production to assembly of the 6,000 BM within definite time limits, there is a tendency for workmen to operate in the same manner when working with the small member. While we glue members of increasingly greater cross-sectional area, we also compete with solid timbers for even the small 4 x 8-inch cross-section. Minimum

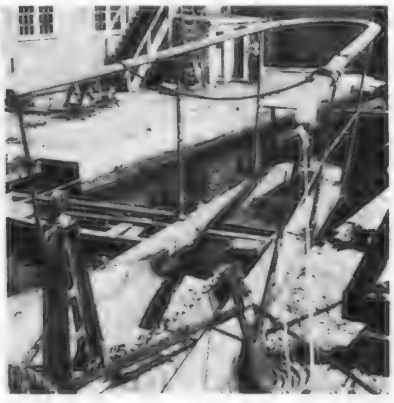


Fig. 5A.—Fabricating small boat framing.

Fig. 5B.—Laminated arches for a huge area roof of church.

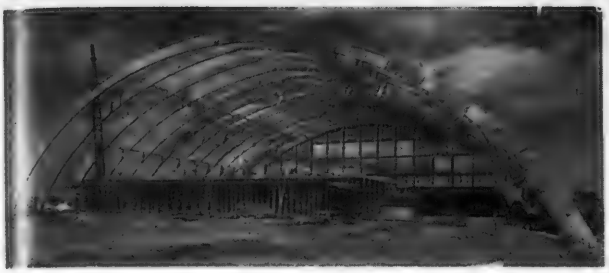


Fig. 6.—Arches for Jai Alai Fronton, Riviera Beach, Fla., have 247-foot span and were world's largest at time of erection.

assembly time must be observed as well as the maximum.

Curing time and temperature relationships may be compared with the shutter opening and speed relationships for a camera. The same quality picture can be obtained with one opening—speed relationship as with an entirely different opening and speed setup. This analogy helps to foster an understanding of the handling of waterproof adhesives.

Compressometers, torque wrenches, thermocouples, scales for checking weight of glue spread, and automatic recording wet and dry-bulb equipment are some of the tools used by the modern timber fabricating plant to determine the value of their laminating procedures.

The 247-ft. span wood arches of Fig. 6 created a world's record and also a gluing problem quite different from that experienced in the furniture and plywood industries.

g. Storage after gluing: Prior to actual finishing of their surfaces, timbers are stored under conditions conducive to further glue line curing (Fig. 7). Knowledge of the effects of shrinkage and swelling do much to prevent damage to a quality product at this stage.

h. Finishing: Selection of samples for testing of glue-line adequacy is accomplished during finishing. Best indication of the dry shear strength of the laminated member can be obtained by the ASTM block shear test (6) (Fig. 10). Average shear strength and per cent wood failure at the glued joint, together with the accelerated aging or cyclic delamination test (7), give a reliable indication of what service performance can be expected of the member. Samples are taken from the ends of production members and are the basis for final acceptance or rejection.

Of course the procedure of testing a sample from the end of a member is not enough. Quality control must be more than a selection of and evaluation of test samples. Inspection and evaluation at all intermediate steps is necessity. Surfacing, drilling (Fig. 8), staining, and varnishing are other operations performed at this stage.

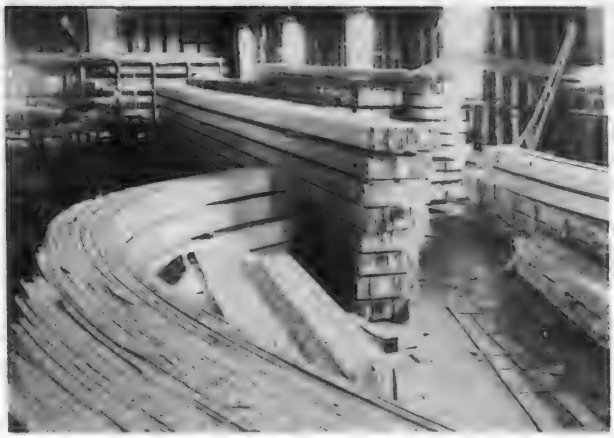


Fig. 7.—Timbers are stored before finishing to aid glue line curing.

i. Loading for shipment: Many depressed-center and idler rail cars are used by the laminating industry in transporting huge structural framing members. The shape as well as the size of members demand unusual truck, rail, and water deliveries (figs. 9A, 9B, and 9C). Ingenuity and caution are needed to meet shipping clearances and blocking specifications. Spot-checking of piece counts and the wrapping protection offered the members are other concerns of quality control in this last step of the laminating procedure.

A quality control manual suggests fields for viewing and measuring the quality within these nine areas of the fabrication process. Quality of materials and workmanship is also checked for individual jobs. This procedure is the basis for saying that quality control data is collected in two ways: first, with respect to the general techniques and procedures of laminating, and second, with respect to specific individual jobs. Daily reports by the chief inspector form the basis for a weekly report by the chief engineer to management.

Fig. 8.—Drilling laminated members before final finishing.

Fig. 10.—Measuring dry shear strength by ASTM block shear test.

3. Assistance in the establishment of proper production procedures and product specifications: Information obtained by quality control may indicate a need for change in design, methods of production, or both. It may indicate that a desired quality level is not obtainable with the process or equipment now in use. On the other hand, it may indicate that a process or machine under dispute can actually produce the required quality.

Investigations are conducted on particular operations of a long-term nature, not within the scope of production personnel who are more concerned with the day-to-day difficulties of production.

It has been stated that the fashionable love of change is unchangeable. Modern man must keep in step or in tune with his time. Don't let this philosophy cause you to make a hasty decision which can lead to trouble. There are certain things which make glue stick, things which skilled artisans knew as early as the days of the Pharaohs of Egypt (8). A change should not be made in procedure merely for the sake of a change.

Directly through the sampling of finished products and indirectly through the investigation and analysis of field performance, the background exists for quality control to assist in the establishment of techniques and procedures conducive to preventing defective members from being made.

The formation and use of procedures that have proven that quality can be achieved is an assurance of a quality product.

4. Assistance in the training of production personnel in quality practices: When a need for change in method of production shows itself,

Fig. 9A.—Truck delivery of completed arches.

quality control should participate in the training of production personnel. This usually takes the form of classes for supervisors or demonstrations for workmen. Close contact with workmen and discussion of mutual problems can result in action to raise quality levels.

5. Liaison between production and engineering: As a liaison between production and engineering, quality control serves as a link to enable reliable information to get back to other departments concerned with design or methods of production.

It must be acknowledged that every plant workman is capable of submitting worthwhile ideas. Their suggestions may not only cut the cost of production but can raise quality and make shipment or field erection easier.

In the normal functioning of the quality control department, information acquired from the production department is made available to others. In turn, quality policy is transmitted to production for their use in quality planning.

6. Analysis of service reports: The follow-up of service reports and customer complaints is in effect a defect preventative. If a mistake must be made, make it a new one.

Service reports come in various forms from district offices and salesmen, as correspondence from customers or architects, and as a result of field inspection trips by management and quality control personnel.

Salesmen intent on establishing a favorable "climate" for the product frequently have difficulty separating those objections advanced for "horse-trading purposes" from those that are deep-seated convictions. Salesmen seldom report an instance where a prospect, seeking the best possible deal, told what he liked about the product.

It is not meant to under-estimate this "word from the firing line" but it is absolutely necessary that quality control personnel visit the field often. Then they can appraise for themselves the company products with reference to competitive products.

7. Action as a trouble-shooting service: Periodic reports to management by quality control enables control to be exercised over the entire organization. The weekly report covers the nine areas of observation during fabrication. There also are field inspection reports for study. Information on shop and field troubles or customer reactions are passed on to appropriate departments by these reports.

The object of these channels of communication is to keep departments fully advised. They then have an opportunity to voice their opinions and to recommend changes that would improve the end product.

Field complaints are immediately routed to quality control. It is their task to investigate that claim, first with departments within the company and then with the customer. A field inspection may be necessary. Whatever the disposition of the claim, the all-important thing will be the follow-up used to make persons within the organization aware of the trouble and desirous of taking steps to prevent re-occurrence.

Quality control does not take away from production personnel any duty or responsibility. Production is still responsible for correct and proper work. The quality control department supplements these production efforts, using their quality control manual as a guide. Problems arising daily, if not capable of being solved through conferences with department heads, are referred to management for disposition.

Management has, in quality control, a means of being eternally vigilant over the production of the company products. The wide acceptance of the product is indication that good practices and established quality controls are working. The customer has available a strong and durable product in structural glued laminated timber. Increased use of waterproof adhesives and preservative treatments are opening new markets for our product, creating additional reasons for the existence of quality control.

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Fig. 9B.—Loading laminated arches for rail shipment.

Fig. 9C.—Shipment by water is also used in delivering arches.

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Discussion

B. B. Lane (The Lane Co.): How much responsibility is placed on production personnel for poor quality? Is responsibility closely defined?

Mr. Rhude: Quality control has a responsibility to see that only quality products go to the customer. The ultimate responsibility, however, is clearly defined and is with the production department.

Alan Marra (University of Michigan): You have given an excellent review of the laminating process and have indicated the points in the operation where vigilance is necessary in maintaining proper control on quality. Would you amplify the word "proper" by indicating what is properly applied pressure, and how is vigilance implemented to assure that pressure is properly applied?

Mr. Rhude: Pressures of 150 psi on softwoods and 200 psi on hardwoods are common. Screw clamps are tightened first by air-operated wrenches progressing either from the center of members and both directions to the ends or from one end to the other. A hand-operated torque wrench is used to check for adequacy and uniformness of pressure using the same sequence of progress.

John Reno (Pacific Lumber Co.): Do they use edge-glued joints to make full-width members in laminated beams?

Mr. Rhude: When 12-inch and wider members are necessary, it is common to use two or more boards to obtain the width. For lesser widths, commercially available lumber can be obtained full width. Whether or not the two or more boards are edge-glued will depend upon the method of loading of the structural member being fabricated. It can be stated that usually in a horizontally laminated beam, where the loads act perpendicular to the plane of the laminations, edge-gluing is unnecessary. In vertically laminated members where the load acts parallel to the laminations, edge gluing may be necessary to insure adequate shear strength in the member.

T. E. Hawkins (Hill–Clark–Francis Ltd.): How many are employed in the quality control department compared with production department?

Mr. Rhude: Personnel from our Engineering Department are utilized for certain quality control functions, thus making it a bit difficult to determine the exact number of full-time employees in quality control work. I would estimate about one full-time employee for every 40 production people.

Glue Spreading by Spraying Method

A. H. RAUCH

Product Development Engineer, U. S. Plywood Corp., Seattle, Wash.[1]

Describes a spraying technique developed for applying glue with a maximum weight of spread variation of about 5 per cent. Best results were obtained with a diagonal row of stationary spray guns mounted over a conveyor moving veneer at about 80 lineal feet per minute. Glue viscosity of about 1000 cps and atomizing air pressure of 15 psi were established as desirable conditions with this arrangement.

Introduction

INVESTIGATION OF THE PRESENT spreading technique for applying resin glues in the plywood industry of the Northwest produced interesting information showing a need for improvement in this field.

Plywood plants estimate the glue waste of rubber covered, grooved roll spreaders now in use to be about 15 to 25 per cent. This loss is due to slopping and spattering at high operational speeds, excessive spread on thin or unevenly peeled veneer, excessive spread around knots, other defects and edges of the veneer, waste involved in the washing down for changeovers in production, and trim. At a glue line cost of about $6 per M of 3/8-inch plywood, this loss amounts to about $1 per M. The trim is constant at about 7 per cent and cannot be eliminated but other glue losses could be lowered or eliminated, in theory at least, by uniform spreading.

In addition to the glue, there is a veneer loss estimated at about 5 per cent (depending on the quality of peel in the plant) due to thin veneer which cannot be spread at all or is overspread so as to cause a "blow" or poor glue bond condition.

Present roll spreaders are adjusted by "doctor" roll settings and pressure of the rubber rolls against the veneer to control the amount of glue being applied. The rubber applicator rolls are grooved to certain specifications, the grooves theoretically emptying themselves when forced against the veneer and thus depositing the proper amount of glue. The spreader operator adjusts the machine by eye in order to get what he considers the proper setting on each pair of rolls, sometimes weighing, spreading, and reweighing a test piece to check the adjustment. This system does not result in uniform spreading for the following reasons:

1. The thickness of the test piece can only be an average and it may or may not have been calipered before using. Assuming the test piece is average in thickness, veneer measuring .015 of an inch, over or under, will pick up more or less weight of spread due to the variation of pressure in passing between the rubber applicator rolls at a constant setting. A variation of ±.015 of an inch is not uncommon and wider fluctuations often occur resulting in this veneer being improperly spread or discarded after spreading.

[1] This study was made while author was wood technologist at Plywood Research Foundation, Tacoma, Wash.

Author: A. H. Rauch holds B. S. from Oregon State College, was previously employed by Plywood Research Foundation, U. S. Forest Products Laboratory, and Weyerhaeuser Timber Co.

2. The difference in weight of spread between top and bottom rolls may be considerable as this adjustment is made by eye with no provision for actual measurement of the respective amounts being applied to the two surfaces of the veneer.

3. Variation in the smoothness of veneer surfaces will result in fluctuations in weight of spread as the controlling pressure acts somewhat as a wringer tending to force the glue off the high spots and into the lower areas. This is particularly noticeable in much of the roughly peeled second-growth Douglas-fir now used in the Northwest.

Since it is generally accepted that controlled uniform spreading is essential to good bonding, variations such as the above further indicate the need for an improvement in spreading technique. In developing an improved spreader, it was considered desirable to include an arrangement for continuous application to veneer moving with the grain (the 4 ft. dimension) perpendicular to direction of travel. A spreader capable of this would greatly facilitate continuous assembly and give impetus to the possible development of continuous pressing. In addition, it would permit a much higher rate of spreading and the possibility of less labor costs.

The problem might therefore be specified, briefly, as the development of an improved spreader to apply glue more uniformly on veneer moving in a continuous line at a rate of about 80 ft. per minute.

Materials Used

The study was limited to exterior phenol-formaldehyde resin mixes, currently approved by the Douglas Fir Plywood Association, although it was visualized that much broader applications covering other glues and products might develop. In working with the exterior resin mixes available, it was found that furafil-extended glues were particularly well adapted to our needs, being relatively low in viscosity (about 1000 cps) and increasing very slowly in this property with time.

Furafil glue mixes also appeared to be relatively free of hardened or poorly dispersed globs with which to contend. This advantage may not be of great importance as it was assumed that a continuous straining system would have to be employed to assure clean, lump-free glue at the gun nozzles.

Viscosity ranges of the glues used varied from about 500 cps to about 2500 cps, or T–U to Z–Z1 on the Gardner Holdt Scale. Some exploratory work was also done at a higher viscosity of about 10,000 cps.

Glues were water miscible and the equipment was thoroughly washed after each run. It appears that the system could be out of use for several hours, or perhaps overnight, without washing down provided the lines, pumps, pot, etc. were full so that air could not get to the glue and cause "scumming" at any point past the strainer. During such a layover period, the fluid nozzles would be closed by a conventional needle valve and at startup some cleaning of the nozzles might be necessary.

Production run rotary-cut Douglas-fir veneer under 5 per cent in moisture content was used for gluing and bond test studies. Glue manufacturers' directions were followed concerning weight of spread, assembly time, and pressing schedule unless otherwise noted.

For convenience, much of the uniformity and loss to air work was done on heavy Kraft paper rather than veneer.

Furafil extended mixes were used for most of the spraying work and a typical example is listed below:

Material	Parts by Weight
Water at Room Temperature	135
Furafil	70
Short Mix	
Caustic Soda (50% Solution)	20
5 Minute Mix	
Soda Ash	15
10 Minute Mix	
Water at Room Temperature	20
Short Mix	
Phenol Formaldehyde Resin (45% Solids)	500

(Advanced alkaline water miscible product supplied by adhesive resin manufacturers in the Northwest.)

Mix 5 minutes and cool to room temperature before use.

Spreading Systems Explored

Spraying seemed to offer the best possibility for accomplishing the desired results and therefore most of the work on improved spreading has involved spraying systems.

Continuous paint spraying systems were examined in cooperation with the Binks Company and the first major effort at uniform spreading was made employing the Binks Model 60.4–4 gun reciprocating machine (See Fig. 1). This machine had 4 guns mounted about 8 inches apart on a reciprocating crossbar with cam actuated needle valves for stopping the flow of glue and air as the guns moved past the edges of the veneer. The guns were attached to a chain and carriage which moved them over the 4-foot wide conveyor at a rate of one crossing per second. Since the sprayer operated both ways, there was approximately two passes across the conveyed veneer in two seconds.

This machine pointed up several problems to be overcome in order to spray spread glue uniformly. The first difficulty encountered was the variation of glue output with changing viscosity when using a pressure pot. Friction or flow resistance increases with viscosity and glue viscosity changes with temperature, time after mixing, and to some extent from batch to batch. Therefore, the constant air pot pressure supply system resulted in variable output. Metering type pumps were checked and a simple gear pump was found to effectively move the glue through the guns at a uniform rate over the viscosity range being used.

Another difficulty with this type of machine was the variation produced in blending the spray fans or patterns of adjacent guns. The area of spray pattern blending caused streaking or heavy and light patterns in the glue spread. This equipment originally was designed for painting where the fluid will level of its own accord; however, with glue application the problem is different.

A further serious problem with the reciprocating crosshead machine resulted from the movement of the spray guns across the veneer and back while the veneer was being conveyed forward. This produced a V-shaped path for each round trip of the crosshead rather than parallel lines. The V path resulted in a variable amount of overlap and weight of spread which cannot be tolerated if there is to be uniformity.

Spray patterns have a tendency to vary slightly from one gun to another when adjusted to fan shapes. By careful gun selection and adjustment, much of this variability can be eliminated but there is no assurance of absolute uniformity across the width of a spray fan 8 to 12 inches wide.

In order to overcome the above variability and blending problems, a system of controlled overlapping of the spray fans was investigated. This is the same principle that has been used for many years by painters in hand spray painting and it became the basis of our next trial sprayer.

This second machine took the form of a rotary arm with hollow hub supplying the glue and air, and the tip carrying a spray gun. The 4-foot arm was rotated at about 60 rpm with the glue sprayed continuously onto veneer conveyed under the spray area. This system produced overlapped spray swaths but weight of spread was greater toward the edges of the 4-foot veneer core. The increase in this area was caused by the path of the moving spray gun tending to parallel the direction of veneer travel and overlap to a greater extent as the arm moved toward or away from the center line of the conveyor. A longer arm would

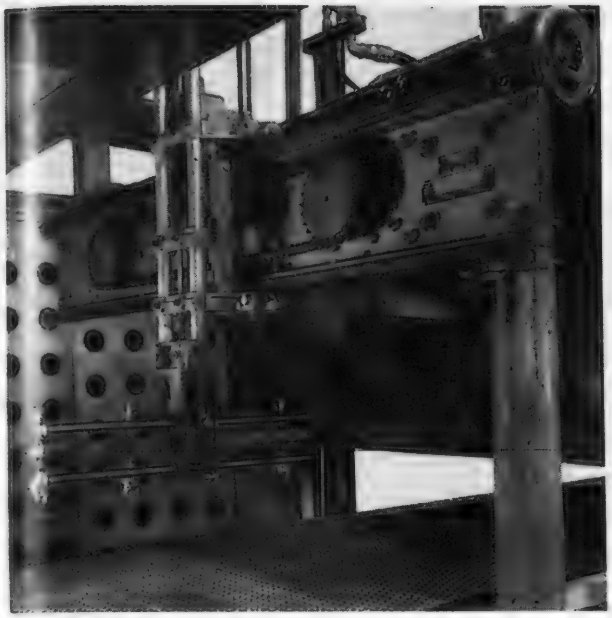

Fig. 1—Binks model 60.4 reciprocating sprayer with four-gun crosshead.

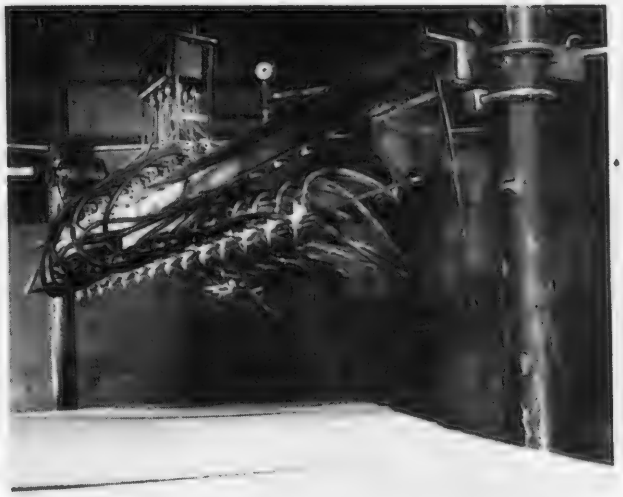

Fig. 2.—Stationary spray spreader viewed along veneer conveyor showing staggered row of guns, air manifold, gear pumps, and glue supply pot.

alleviate this problem but sagging and space for the machine might then become critical.

A variation of the rotating arm machine was next designed to overcome the effect of spread variation caused by the above mentioned circular motion. The new machine consisted of two telescoping arms (more could have been included) following a large cam designed to move the guns perpendicular to the direction of veneer travel in crossing the 4-foot conveyor.

This third machine gave fair uniformity and straight line motion across most of the 4-foot width, but there was some change in angle of travel and increased weight of glue spread near the edges. A larger improved cam would have taken care of this nonuniformity along the edges, but with the rotating speed of about 60 rpm there was considerable stress on the cam with indications of a need for high quality workmanship and material in this area.

Since overlapping was found to be a requisite of uniform spray spreading and moving guns posed mechanical problems, a staggered stationary gun setup was next explored. By using smaller fluid nozzles, good spray patterns about 12 inches wide could be obtained. Guns were spaced 3 inches apart across the conveyor with the 12-inch fan providing a 3/4 overlap and four coats to any one point of the material being spread.

Details of Stationary Gun System

In all spraying work the individual gun was very important and the type used for the stationary setup will be described in detail (Fig. 2). It was a Binks Model 21B consisting of a mounting bracket, spraying head with fluid and air entry and outlet points, and spray pattern adjusting valve. This model has no needle valve but can be supplied with same manually or air operated. It is of the external mix type; that is, the air atomizes the stream of fluid after it leaves the nozzle. The pattern of the atomized fluid can be adjusted by a valve which regulates the amount of air passing through the wing outlets.

Fluid nozzles with orifice diameters ranging from .040 to .173 of an inch were used with various air nozzle combinations. Viscosity and rate of flow of the glue determined the best nozzle size and combination. The stationary system described in this section produced very satisfactory results with Binks 67 fluid nozzle (.086 inch in diameter) and 67P air nozzle when applying 30 pounds of glue per 1000 square feet with the veneer conveyed at about 80 feet per minute. Glue viscosity of about 1000 cps and a pumping rate per gun of 225 cc (about .06 gallon) per minute was used in making the above selections.

The mounting bracket consists of a ½ inch hole and set screw. This facilitated gun arrangement in that all guns were slipped onto a ½ inch steel rod and positioned according to the desired spacing laterally with the rod angled along the conveyor to give the proper spacing in that direction.

Several gun positioning arrangements were explored and it was found that a spacing of 3 inches laterally and about 6 inches along the conveyor was satisfactory. With this spacing the supporting rod and guns cross the conveyor at an angle of about 25° (Fig. 3). Various mounting heights were tried and 18 inches was established as a favorable distance in that it produced a 12-inch wide fan. With this setup each gun pattern overlapped the next by 9 inches or 3/4 of its width and the veneer received glue from four different guns in passing through the spray spreader, thus tending to equalize momentary pattern distortion or

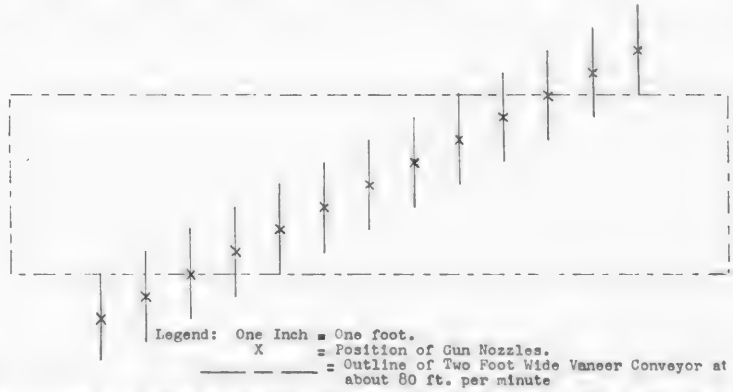

Fig. 3.—Top view sketch of stationary spray system showing center line of spray patterns for each gun and outline of two-foot wide conveyed veneer.

Table 1.—UNIFORMITY OF OUTPUT WITH CHANGING VISCOSITY WHEN USING OBERDORFER SERIES IN GEAR PUMP

Viscosity cps	Amount of Flow Over Constant Time Period cc
650	2178
2250	2175
10000 (Approximately)	2170

variation which might occur in any one gun.

In general, the higher the percentage of overlapping the more uniform the spread, but more overlapping requires a lower rate of application from each gun if a given weight of spread is to be maintained. This presents problems in that lower spraying rates require smaller, more easily restricted fluid nozzles and it is difficult to adjust such rates into a uniform spray fan. In this respect the 3/4 overlap appeared to be a good compromise permitting the use of a .086 inch diameter fluid nozzle and adequate fan adjustment.

The pump used for most of the glue metering was a 1/8 inch bronze Oberdorfer Series I gear pump with oilless carbon bearings. Modification of this model may be required for a production unit but performance was satisfactory for our laboratory and pilot scale work. One pump supplied each gun and all pumps were powered from a common line shaft utilizing high speed chain and sprockets. The pumps were supplied from a common pot by means of 3/8 inch copper tubing while 3/8 inch rubber hose was used between the pumps and guns. Glue supply pot and pumps with drive mechanisms were mounted above and along the length of the framework supporting the guns.

Table 1 gives an indication of the uniformity of output with changing viscosity when using the above pump.

If a supply pot with constant air pressure was used to move the glue in the above viscosity ranges, the variation would have been too great to warrant consideration. Pump speeds were varied from 45 to 200 rpm in covering the methods explored. About 45 rpm was found to give the desired weight of spread with the stationary setup described in this section.

The stationary Model 21B gun with 67 fluid nozzle and 67P air nozzle requires an air pressure of about 15 psi to properly atomize glue of 1000 cps viscosity pumped at a rate of about .06 gallon per minute. At this pressure each gun will demand about 4 cubic feet of air per minute. If 22 guns were used to cover the conventional 50-inch wide core veneer, the requirement would be 88 cubic feet per minute of 15 psi air. If 50 pound air was used, each gun would require about 13 cubic feet, or a total of 286 cubic feet per minute for 22 guns. The air manifold for the stationary sprayer consisted of a 2-inch pipe with 3/4-inch end inlets and ½-inch outlets, each outlet supplying 2 guns. The manifold was mounted above the level of the guns along the framework supporting them and 5/16-inch rubber hosing connected the outlets to each gun. This arrangement was gauge checked and found to give uniform air pressure at each gun. The air supply should be well filtered and free of water to avoid plugging of air jets or glue dilution.

Results with Stationary Spray System

After proper adjustments, the stationary system described in the previous section applied glue spreads that appeared uniform when examined visually. A test method previously used in checking spray uniformity was now employed on the stationary spreader. It consisted of weighing and mounting a row of 2 by 2 inch hardboard squares on a pallet, conveying the pallet through the spray area, and reweighing. The weight increase of the squares was a measurement of the uniformity of spread. Sufficient squares were included to extend across the width of the spreader plus several to cover each edge.

If weighed immediately after glue application, evaporation rate was quite high resulting in a weight change in the time required to handle the 20 squares. The curve of evaporation weight loss versus time rises rapidly for about 40 minutes and gradually levels to a very gentle slope at about one hour. Weight measurements after spreading were therefore delayed about one hour to minimize the effect of evaporation loss. As a result, these readings could not be used to determine weight of spread and a separate 6 by 6 inch square was included for this purpose.

Results of a uniformity test on the stationary spray system are listed in Table 2 with the 2 by 2 inch specimens numbered 1 to 20 having been oriented across the conveyor in passing under the spreader.

Table 2.—RESULTS OF UNIFORMITY TEST ON STATIONARY SPRAY SYSTEM

Specimen Number	1	2	3	4	5	6	7	8	9	10
Weight Increase* (grams)	.12	.14	.15	.16	.18	.20	.22	.22	.20	.21
Specimen Number	11	12	13	14	15	16	17	18	19	20
Weight Increase* (grams)	.20	.21	.22	.22	.21	.21	.19	.16	.14	.10

*After evaporation of about 50% of weight of spread.

Table 3.—RESULTS OF STANDARD BOIL TEST SPECIMENS CUT FROM MATCHED PANELS, ONE SPREAD BY LABORATORY ROLL SPREADER AND OTHER BY SPRAY TECHNIQUE

Number	Laboratory Roll Spread		Spray Spread	
	Load lbs.	W. F. %	Load lbs.	W. F. %
1	106*	85	196	86
2	158	88	126	82
Average	132	86	161	84

*Each value is average of 20 test specimens

The data in Table 2 shows very good glue spread uniformity in the central 20 inches of the machine. The variations in this area were of no great significance in light of the tolerances included in the weighing method. The decreasing weights on each edge resulted from the overlapping arrangement wherein increasingly fewer coats were applied toward each end of the row of squares.

Effect of spray spreading on glue bond was studied by making up matched panels, one of which was spread by a laboratory roll spreader and the other by the spray technique. The 3/8-inch 3-ply panels were made from average quality Douglas-fir veneer. Gluing conditions were maintained according to manufacturers' specifications and veneer moisture content was under 5 per cent. Results of standard (CS45–55) boil test specimens cut from these panels are listed in Table 3 and indicate no adverse effect from spray spreading.

The effect of spray spreading .010 to .025 inch under average thickness core veneer on glue line quality was also studied. Results of this work indicate that good bonds can be attained with 1/5 to ½ of the core of a panel .020 inch thin provided the veneer has been uniformly spread. This was also assuming the panels would be pressed at one per opening or with average thickness veneer in the adjacent panel if pressed at two per opening. There was some indication of lower bond quality when thin pieces of two panels were aligned directly opposite one another and pressed two per opening.

Results in Table 4 verify the above observations and also point toward further interesting work that could be done in comparing spray and production roll spreading of various thickness and quality veneers.

In determining weight loss to the air with the stationary sprayer, it was assumed the edge losses would be picked up by troughs or moving belt type wiper arrangements. The air loss measurement was made by preweighing a

small roll of Kraft paper sufficiently wide to take in all the spray area and reweighing the roll after a given lineal footage had been spread. The calculated loss to the air was 6.9 or approximately 7 per cent. There is a possibility of recovering most of this with the proper equipment but its re-use would depend upon the effect on glue bond. The air loss would not appear to be at all prohibitive in light of the estimated 10 to 20 per cent (over trim) loss now tolerated with conventional spreaders.

Core veneer .020 inch thin is usually rejected in production because of improper spreading. The results in Table 4 indicate that this veneer might be utilized since it can be satisfactorily bonded when spray spread uniformly.

The stationary sprayer permits the continuous spreading of veneer with grain direction either perpendicular or parallel to direction of travel at speeds around 80 lineal feet per minute. This arrangement should facilitate development of automatic mechanical layup to replace the laborious hand system now used.

Table 4.—RESULTS OF COMPARING SPRAY AND PRODUCTION ROLL SPREADING OF VARIOUS THICKNESS AND QUALITY VENEERS

Type of Panel	Method of Spreading	No. of* Panels	No. of Specimen	Boil Test Results Load lbs.	Boil Test Results W. F. %
⅛ of Core Veneer .020 inch thin					
Thin Area	Spray	3	30	125	90
Normal Area	Spray	3	30	80	87
1/5 of Core Veneer .020 inch thin					
Thin Area	Spray	3	30	130	96
Normal Area	Spray	3	30	155	97
Controls	Spray	4	40	105	98
Controls from Areas of Thin Core in Adjacent Panels	Spray	3	30	157	93
Controls from Normal Thickness Veneer	Lab Roller	5	100	131	88

*Panels were nominally of ¾-inch 3-ply construction pressed two per opening.

The weight of spread applied can be positively determined by knowing conveyor and pump speeds and adjusted by varying the pumping rate. Positive spread control and uniformity of spread are distinct advantages of spraying over conventional roll spreading, which applies a spread that varies with veneer thickness and quality.

A further advantage of spray spreading is that dual guns could be used to introduce catalyst at the time of glue application. This would permit the use of rapid setting glues and encourage the development of continuous pressing technique.

While it is difficult to establish accurate cost figures on a production scale machine without having designed and built one, it would appear the price range should be about the same as for the conventional roll spreaders now in use. Maintenance should not be any greater than regrooving and recovering costs on rubber rolls which currently amount to about $350 per year over the life of a spreader.

Discoloration of Furniture Finishes[1]

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Describes a test designed to study variables causing discoloration of furniture finishes. Three stratas considered are: the wood substrates, finishing materials applied to the substrates, and possible contaminants which contact the top-coat films. Involved factors discussed are specimen preparation, seven in-use exposure conditions, effect of exposure to ultra-violet radiation, and recommended procedure for discoloration tests.

THE DISCOLORATION OF FURNITURE FINISHES involves a pattern of predictable behaviors that can be prevented or controlled by a proper selection of materials and by an understanding of the processes of discoloration.

There are three stratas that must be considered with regard to discoloration. They are: the wood substrates, the finishing materials applied to the substrates, and the possible contaminants such as oil which come in contact with the top-coat films.

Panel preparation and the equipment used to simulate and accelerate "in-use" conditions that cause discoloration are very important. Discoloration is often a combination of many factors and a complete understanding of each of the above stratas as well as their inter-related behavior must be understood before a complete evaluation can be made. The test described in the following pages was designed to study these variables. A discussion of the involved factors will be made in the following order:

1. Specimen preparation—individual material, complete systems.
2. Methods of exposure.
3. Discussion of effects resulting from exposure to ultra-violet radiation.
4. Recommended procedure for discoloration tests.

Specimen Preparation

With sample preparation, it was important that each variable be isolated so that the individual behavior of a material could be determined as well as its contribution to a complete system. The preparation of samples for test, therefore, was divided into two groups: the first, for the testing of individual components making up a system; the second, the complete system itself—wood through rubbing.

The first group was prepared as follows:

Wood: Different species of wood as well as different samples within a given specie will discolor in varying degrees. It will be found, however, that samples of any given specie will act in a like manner, the degree depending on tree location, age of sample, etc. Panels for discoloration work were all from the same piece of face veneer. In this manner, the variables, other than wood, were controlled more closely. Random sampling and exposure of veneers is suggested to familiarize the tester with discoloration patterns within a specie.

Stain: Whatman #1 filter paper cut to a 2½" x 8" size is used. This permits the insertion of the filter paper into a standard test envelope (Fig. 1). These envelopes have convenient per-

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forated sections that can be torn out for four intervals of exposure. The filter paper was dipped and slowly withdrawn from a fresh sample of stain under test. All stains fade. It was often found that the same color stain, produced by different manufacturers, will vary considerably in color retention. The object of this test was to measure relative degrees of discoloration as well as to observe the faded color.

Toner: Toners were sprayed on 2½" x 8" glass slips to full hiding and when dry, inserted into envelopes for exposure.

Sealers—Lacquers: 2½" x 8" glass slips were coated with a white lacquer that tests show will not change color. The opposite sides of the glass slip were cleaned and coated with three heavy coats of lacquer or, in the case of sealer, one heavy coat. It has been found that coating the back of glass slips will give a more faithful reproduction of the behavior of lacquer over blonde finishes. White Carrara glass can be used. However, it makes the storage of samples bulky and difficult to handle.

Contaminants: Contaminants, such as oil, rubber, polish, various masking and cellophane tapes, etc. were placed in contact with a 3-coat lacquer system prepared as described above for a period of 24 hours or longer and then exposed.

The second group of panels comprising complete systems were prepared as follows: In this test, six exposure conditions (explained in the following section) were tested. It was necessary that each of the six panels be from the same piece of face veneer. Large panels, in this case, large enough to yield six 1/4" x 6" x 12" (Fig. 2) 5-ply panels having one piece face veneer were laid up and finish-sanded with 4/0 paper. Panels of walnut, mahogany, maple, oak, prima vera, and avodire face veneer were prepared and

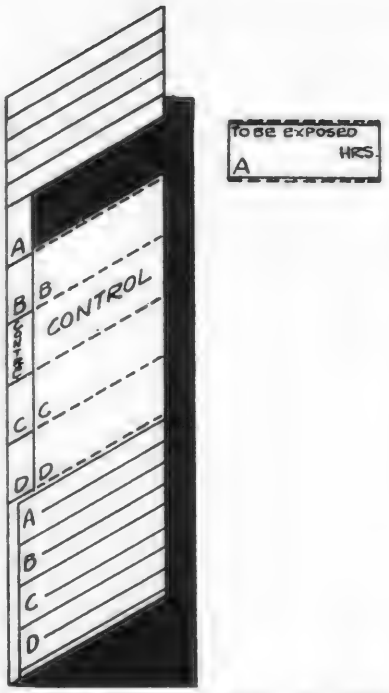

Fig. 1.—Standard test envelope for making exposure studies.

each cut into six panels—6" x 12". This size was selected as it is easy to handle, and will fit the exposure racks of testing services in Florida. The panels used for the exposure tests were prepared as follows (Fig. 2):

a. One inch margins were left on the top and bottom for placement in exposure racks.

b. The remaining 10 inches were divided into 8 sections to cover 8 variables or conditions:

1. Bare wood.
2. Filler over bare wood.
3. Stain or toner over bare wood.
4. Complete system (stain or toner, filler, sealer, lacquer) with amber (Hellige 6+) lacquer known to discolor.
5. Same as 4 with light-fast pale lacquer (Hellige 3–4).
6. Same as 4 with light-fast water-white lacquer (Hellige 1–2).
7. Same as 6 with contaminants placed in contact with the surface prior to exposure.
8. Same as 6 with the incorporation of 1 per cent ultra-violet absorber (based on lacquer solids).

Panel work is generally conducted after the characteristics of the separate finishing materials have been determined. It is suggested that all panel work be carried out with a step system. In this manner, the causes of discoolration can be determined more easily. In preparing panels, it is very important that metal shields, and not paper held down by any of the tapes, be used to mask off the individual steps. Tapes may cause discolorati...

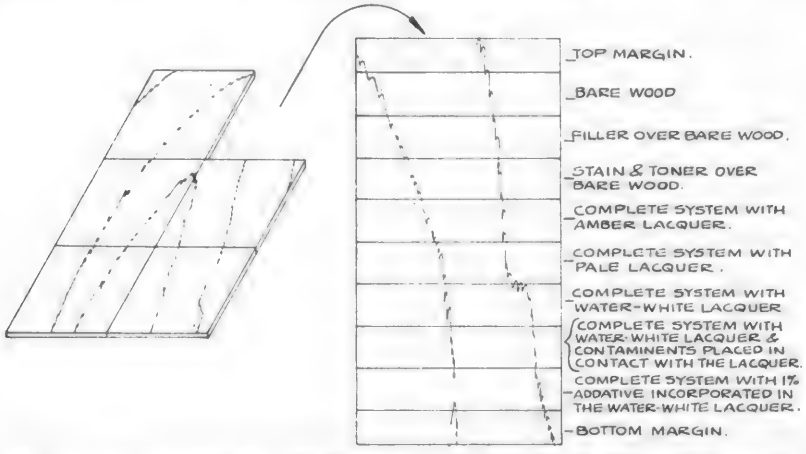
TOP MARGIN.
BARE WOOD
FILLER OVER BARE WOOD.
STAIN & TONER OVER BARE WOOD.
COMPLETE SYSTEM WITH AMBER LACQUER.
COMPLETE SYSTEM WITH PALE LACQUER.
COMPLETE SYSTEM WITH WATER-WHITE LACQUER
COMPLETE SYSTEM WITH WATER-WHITE LACQUER & CONTAMINENTS PLACED IN CONTACT WITH THE LACQUER.
COMPLETE SYSTEM WITH 1% ADDATIVE INCORPORATED IN THE WATER-WHITE LACQUER.
BOTTOM MARGIN.

Fig. 2.—Panels for testing the complete finishing system, from bare wood through rubbing.

Methods of Exposure

The objective of this work on discoloration was to be able to predict accurately, in the shortest possible time, the effect of years of "in-use" exposure, both average (subject to diffuse sunlight) and severe (direct sunlight). Walnut, mahogany, maple, oak, prima vera, and avodire panels prepared in a manner described in the previous section were exposed to the following conditions for periods of three months and six months, during the months of August to Feb.

A. Under glass and enclosed in a rack facing south at an angle of 45°. Location—Great Lakes area.

B. Along a wall, facing west and in such a manner that only diffuse sunlight would reach the panels. Location—Great Lakes area.

C. Wrapped in aluminum foil and paper and allowed to remain at room conditions.

D. Exposed for 24 hours to a carbon arc.

E. Exposed for 24 hours to cold ultra-violet lights, 6 inches from the lamps.

F. Exposed under glass, 45°, and to the south, in Florida for periods of three months and six months.

G. Additional exposure conditions were 140° F. for three days (no moisture conditioning) and wrapping panels with every type of paper and packing material that they would be likely to come in contact with and exposed for one week at 110° F. and 80 per cent R. H.

Condition A gave an average of exposure conditions for northern climates. This condition also formed a basis for comparing northern exposures with the more severe southern exposures (Cond. F). Close observation was made of the panels under condition A. It was assumed that the panels exposed to the northern climates would behave in the same manner as those

in Florida, with the possible exception that the Florida panels would change faster. Actual test results showed that the panels under Condition A discolored in a few days. A comparison of the panels exposed three months and six months under Condition A to the same periods under F proved to be equal.

With the exposure of house paints, automotive finishes, etc., there may be an advantage to the more intense and constant ultra-violet exposure of the sun in Florida. With wood and furniture finishes, there is no particular advantage. It was evident that if any part of a finishing system applied to wood, or contaminants that come in contact with the lacquer film, will discolor, it will be evident in less than a week—northern or southern exposure. Longer exposures, up to four weeks, are recommended to cover unusual conditions, however.

Condition B gave an average of exposure conditions for furniture that is ideally placed and subjected to diffuse sunlight. Lacquers that will discolor, and contaminants that cause discoloration, change at a slower rate than during direct exposure. The change in the lacquer was noticeable in two weeks. The change at the end of six months was not as dark as seven days' direct sunlight exposure.

Contaminants, such as oil, turned as dark in three weeks as the direct exposure panels (direct exposure took only a few hours). The wood itself changed very slowly and at the end of six months, a slight darkening was evident. Diffuse sunlight will not offer protection for the factors of a finish that will change under direct sunlight. It only slows the rate of change.

Condition C was the controlling factor. Any change that took place could not be controlled except possibly by refrigeration, which was not felt necessary.

Condition D: One of the most widely used methods for mechanically reproducing ultra-violet radiation of the sun is the violet carbon arc. These arcs produce a complete spectrum from 279 to 20,000 millimicrons. They are easy to use and give quick results. The pattern of discoloration produced by the carbon arc is very similar to that produced by sunlight exposures. The principal difference in the results of exposures was with lacquers. The carbon arc seemed to burn the amber lacquers.

To test this condition, thermocouples were placed under the face veneer of walnut, mahogany, oak, and prima vera panels at the time they were laid up. This placed the thermocouples in a position to record the temperature under the finish and first layer of veneer. The ambient temperatures registered by a free thermometer (average temperature with blower on and off was 104° F. and the temperature (avg. blower on and off) of a thermometer embedded in a black panel was 177° F. The average recorded temperature of the panels was as follows: walnut 211° F., mahogany 197° F., oak 175° F., and prima vera 138° F. Further testing indicated that the burning of lacquers that normally discolor and the "speeding-up" of discoloration caused by contaminants was the only effect the heat had on the panels.

The principal objection to the carbon arc equipment is the high initial cost that would require the constant use which exceeds the normal needs of the average furniture manufacturer. Because of the nature of furniture discoloration, less expensive methods will adequately satisfy all needs.

Condition E: Early work directed to finding a less expensive ultra-violet light source prompted the use of sun lamps. The lamps used were inserted in standard fluorescent lamp fixtures and produced wave lengths in the 2800 to 3500 angstrom band. This source of cold ultra-violet was effective in detecting lacquers and contaminants such as oil, etc. that will discolor when exposed to sunlight. It is unsatisfactory for reproducing the discoloration of woods and stains, and for this reason will not duplicate sunlight exposure conditions.

The purchase of these lamps is recommended for the detection of lacquers or contaminants that will discolor blonde finishes. Occasionally, cabinets etc. that are ready for shipping can be exposed for a period of two or three hours. During this exposure period, oils or lacquers, which should not be used on blonde cabinetwork because they cause discoloration, will be detected. The lamps cost only a few dollars. Tests with these lamps should be run in duplicate with direct sunlight exposures until their behavior is understood.

Condition F: Because the sunlight is more intense, the hours of exposure longer, and the atmosphere cleaner, panels were sent to a testing service in Florida for exposure. Exposure of furniture finishes to these conditions is not necessary in order to evaluate the discoloration characteristics of any system. This was covered under Condition A. The cost of this service, however, is quite nominal and exposures of step-panels to Florida conditions will provide additional information.

Condition G: These conditions were set up to cover two variables that are peculiar in nature and do not occur frequently. Some lacquers which failed to discolor on exposure to ultra-violet radiation, when the panel temperatures were only a few degrees above room temperature, discolored under accelerated oven schedules—140° F. 35 per cent R. H. Accelerated conditions of 110° F. and 80 per cent R. H. should activate latent chemicals, etc. in paper and other packing materials that could produce changes in the finish. It is not likely, however, that discoloration will result from these causes.

Discussion of Effects Resulting From Exposure to Ultra-violet Radiation

Dark woods and finishes, without question, change in color. In most instances, however, any change, such as lacquers which yellow with exposure, tends to mellow and beautify the dark finish rather than to cause displeasure. Walnut or mahogany furniture exposed to sunlight changes in color the same as blonde furniture. Blonde finishes, however, usually receive the criticism. Generally, the reason is that as the finish color approaches white, any slight variation will readily be detected, whereas the same degree, or possibly five times the variation in darker finish, will not be as noticeable or objectionable.

With blonde finishes, only one factor should be subject to color change. That factor is wood. Toners and fillers are light-fast and so are good lacquers. Most generally, mismatch problems found in buying a piece of a suite of furniture at a time and similar cases are due to color matching. If there should be a wood problem, the remedy is in the proportion of the toner added to the finish. The following will more adequately describe what can be expected from various types of wood and finishes exposed to ultra-violet light:

Wood (alone): Walnut fades from a chocolate and purple-brown to a light yellow-brown. From this step it continues to darken to a deep orange-brown. The fading takes place quite rapidly.

Mahogany turns a darker red and slowly changes to a deep orange-brown, identical in final color to discolored walnut. Rate of discoloration is slower than walnut and other woods.

Maple changes from white to light brown and to dark brown quite rapidly.

Oak changes from a light brown to a dark yellow-brown and then to a darker orange-brown. Rate of change is quite fast.

Prima vera changes from a light yellow-brown to a darker yellow-brown and finally to a very dark red-brown.

Avodire is the same as prima vera.

The discoloration of wood varied with specie and with the finishing sys-

tem. Unprotected wood started to darken in one day, made the biggest change in the period of 1 to 10 days, and slowly continued to darken. The discoloration of wood under a finishing system is more complicated to detect because of the contributed factors of each material. By carefully removing the finish of exposed panels with lacquer thinner, an examination of the wood indicated the following:

1. Stain alone over wood, filler, toner, and even clear, light stable lacquer, each, alone over wood, slow down the rate of discoloration. The combinations of these materials produce a cumulative effect.

2. Lacquer that yellows when subjected to ultra-violet light actively protects the wood and greatly reduces wood discoloration.

3. Discoloration resulting from wood alone, when under a completely light stable finishing system (for example a modern or limed-oak finish consisting of a transparent toner, filler, and lacquer in which all the natural grain features can be seen, is gradual when compared to any other factor that causes discoloration, such as lacquer and contaminants or to bare wood itself.

Stains: Without question, all stains fade when exposed to ultra-violet light. Quite often, the fading of a stain is offset in a small part by the darkening of wood. The addition of filler over stains, as well as the addition of lacquer, greatly aid the stain in retaining its color. The behavior of stains can often be predicted by exposures of the stain on filter paper. Final judgment, however, should always be made with step-panels.

Toners: Toners are generally made from the automotive type of pigments which are very light-fast. Of the many toners tested, most of which were light in color, none discolored on exposure. Should toners discolor when exposed to ultra-violet light, a reformulation is recommended.

Toners will be found to afford the best protection for the wood. The strength of the toner color will be dependent on the final color desired as well as the degree of protection desired for the wood. The more toner that is applied, the more light stable the wood strata will become. Should full hiding be desired, two or three individual coats with a scuff-sand between coats will allow proper hiding without mottling or crawling.

Care must be exercised with woods that are to be filled so that a full toner coat will not flood the pores, reducing the characteristic features which are meant to be maintained by the filler. With finishes that allow the natural grain to be seen, it is suggested that the tint of the toner be in the direction that the wood will change. This can be determined by exposure tests.

Filler: When coated on filter paper and exposed, fillers will tend to bleach lighter. This bleaching action may be attributed more to a surface chalking phenomenon rather than a fading of the pigments. Fillers should be made from light-stable pigments and caution should be exercised with any filler that shows any degree of fading upon exposure. This is most generally found in dark filler and indicates fugitive oil dyes.

After filler has been applied and wiped off, there remains on the surface a thin film of pigment that will aid in reflecting some of the ultra-violet rays. Although filler alone, over wood, provides little protection, when combined in a finishing system, it has a cumulative effect.

Sealers: Sealers afford little protection for the wood. Agents, such as zinc stearates, which are incorporated in sealers to facilitate sanding will tend to reflect some of the ultra-violet rays. Tests on sealers show they can greatly influence the discoloration of a finish.

In the formulation of a sealer, hard, brittle resins are often incorporated to furnish a suitable sanding medium. Most of these resins discolor quite badly when exposed to ultra-violet light. Regardless of the fact that sanded sealers have less than .5 mil. thickness, their presence should be accounted for.

Lacquers: Lacquers can be divided into three basic groups:

1. Water-white lacquers (Hellige Color 1–2) that are completely free from discoloration when exposed to ultra-violet light and heat.

2. Pale lacquers (Hellige Color 3–4) that are completely free from discoloration when exposed to ultra-violet light and heat.

3. Pale or amber lacquers (Hellige Color over 6) that will discolor when exposed to ultra-violet light and/or heat.

Water-white lacquers, generally speaking, are needed only for very white finishes such as the "sea foam" colors. Early investigations with water-white lacquers showed them to be low in solids (20 per cent) and often poor in print. Some lacquers, classified as water-white because of low initial color, showed marked discoloration upon exposure. The development and use of coconut alkyd resins has greatly relieved this situation.

A point that is often difficult to sell but easily demonstrated is that a heat- and light-stable, pale lacquer is more advantageous to use than a water-white lacquer (on all but a highly pigmented white finish). The advantages are cost, 10–15 cents a gallon less for pale lacquers, and greater flexibility for formulation. As indicated by the panels prepared for the exposure test, in no case could good water-white lacquer be separated from a good pale lacquer on the basis of initial color or discoloration.

Most frequently, discoloration problems find their source in lacquers that discolor. Any company that supplies a lacquer for blonde finishes that will discolor is, without doubt, a questionable supplier. Lacquer discoloration over blonde finishes should be a thing of the past. There are, however, conditions where discoloration is advantageous. On dark finishes, such as walnut or mahogany, the ambering of lacquer not only reduces the discoloring of the stain and woods but adds to the depth and beauty of the finish, producing an old varnish-type appearance.

Lacquer additives: Tests have been conducted on a material that is incorporated in lacquers to reduce or eliminate the photochemical action of sunlight, thus stabilizing the color of wood.

It has been established by experiment, that the ultra-violet end of the spectrum is the principal cause for wood to discolor. The limits of the ultra-violet spectrum are 275–400 millimicrons. Window glass filters out or absorbs all ultra-violet wave lengths below 320 millimicrons and the absorbers used were claimed to have high ultra-violet absorption from 320 to 380 millimicrons. It has therefore been suggested that with the combination of window glass and ultra-violet absorbers, certain woods would be protected from discoloration.

Extensive tests using these absorbers (0.5 per cent based on lacquer solids) have lead to the conclusion that they are ineffective in protecting woods such as red oak, avodire, hard maple, prima vera, and yellow birch. Stronger concentrations (1 per cent or more) will add sufficient yellow color to lacquer to make them undesirable for use on blonde woods.

Aside from the disadvantage of color, the cost of adding absorbers would increase the purchase price of lacquer from 25 to 50¢ a gallon. The writer knows of no additive or antioxident that will stabilize wood's tendency to discolor. At present, the best solution appears to be to study the processes of discoloration and develop a finish according to the requirements.

Contaminants: Contamination of lacquer films can be divided into two periods when the film is subject to contact with materials that will cause discoloration. The first period is that time prior to shipment of furniture.

Unquestionably, the major cause of discoloration during this period is rubbing oils. Little is known about the chemical reaction of oils on lacquer films; however, their results are quite evident.

Tests have indicated that any mineral oil which will fluoresce under a "black light" (3660 Angstrom units) will discolor when exposed to sunlight. Panels that had been rubbed with mineral oil were exposed in a dark room to a "black light". Under this light, large areas of fluoresced oil became visible. These areas, while under the "black light" were outlined in pencil. When the light was turned off and the panels were taken out of the darkroom, only the pencil outlines on the finish were visible. In a matter of a few hours of direct sunlight exposure, the areas within the penciled lines turned yellow.

Work with 14 different oils has produced the following results:

1. All non-water white oils fluoresced and when placed in contact with lacquer, caused the film to discolor when exposed to ultra-violet light.
2. Some water-white oils followed the same pattern as #1.
3. Discoloration is proportionate to lacquer film thickness. As the film thickness increases, more discoloration occurs.
4. Discoloration increases with the length of time that the oil is allowed to remain on the surface. Oil left on as little as two hours and wiped off with naphtha will produce discoloration.
5. Water-white oils that will not cause discoloration can be left on lacquer for months and exposed to ultra-violet light without affecting the color of the film.
6. Discoloration increases with the amount of oil left on the film. Thin films left in contact with a light-fast water-white lacquer will give the appearance that the lacquer yellowed on its own accord. Heavy films of oil cause the lacquer to discolor in such a manner as to leave no question.
7. There is little correlation in discoloration between the time that the final coat is applied and when panels are rubbed. Panels rubbed 2, 4, 6, 9, and 15 hours after the final coat of lacquer showed only a slight indication that this factor was important when rubbing lacquer with a discoloring oil.
8. Oils that discolor lacquer when exposed to sunlight will also change lacquers in the dark. The time period is much longer, however. Heat also accelerates oil discoloration.
9. It is suspected that the mercaptans, phenolics and sulfides, which are acid in nature and present in oils, cause the deterioration of the films.

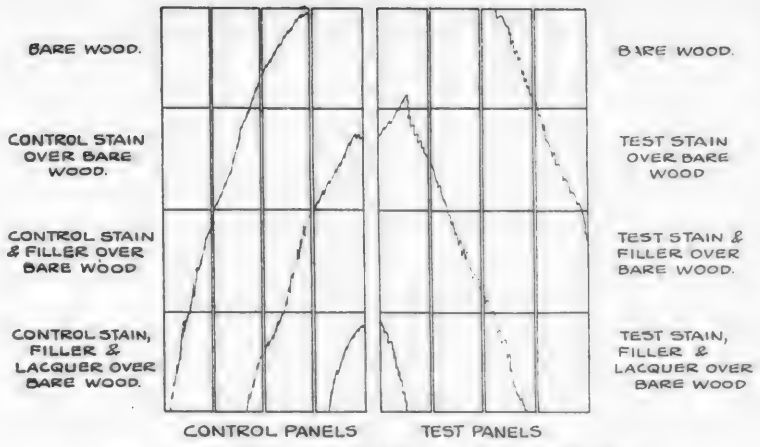
BARE WOOD.
CONTROL STAIN OVER BARE WOOD.
CONTROL STAIN & FILLER OVER BARE WOOD
CONTROL STAIN, FILLER & LACQUER OVER BARE WOOD.
BARE WOOD.
TEST STAIN OVER BARE WOOD
TEST STAIN & FILLER OVER BARE WOOD.
TEST STAIN, FILLER & LACQUER OVER BARE WOOD
CONTROL PANELS
TEST PANELS

Fig. 3.—Test specimens cut into segments for use as step-panels.

Small yellow spots that generally do not follow any specific pattern can be the result of machine oil from air motors, rubbing machines, etc. coming in contact with the lacquer. Lubrication oil used for hinges and other moving parts will show up as spots, or work in under the film and discolor.

The second period when the lacquer is subject to discoloration is while the furniture is in the dealer's and customer's hands. Some of the problems encountered during this time are as follows:

1. Using cheap oil polishes. The tops usually yellow more than the sides because of heavier applications.
2. Using cloths with machine oil on to wipe off the furniture.
3. Allowing drops of machine oil to come in contact with the lacquer.
4. Rubber bases or feet left in contact with the film. This is the most common type of complaint and usually shows up an orange-yellow and with very defined patterns. Oil discoloration is more yellow in color.
5. Masking or cellophane type tapes when placed in contact with lacquer will cause yellowing either while in contact with the film or anytime after the tapes are removed.

The easiest way to control contamination problems is to know exactly what the behavior of the lacquer and entire finishing system is before the furniture leaves the plant.

Recommended Procedure for Conducting Discoloration Tests

A. Prepare several samples of each of the individual materials on the suggested substrates. Step-panels of the complete system can be made on the wood to be used in production at this time or later.

B. Perforated envelopes or similar devices can be used for the individual specimens. Aluminum foil or cutting the test specimens into segments (Fig. 3) and removing a segment after the required exposure can be used for step-panels. The following exposures can be made:

1. Expose, under glass and facing south, to direct sunlight, either vertical or at an angle of 45°, one set of specimens for a period of 3, 6, 9, and 12 days and another set for 7, 14, 21, and 28 days.
2. Expose to violet carbon arcs for periods of 8, 16, 24, and 32 hours. Most finishing houses have this instrument that is available for exposures.
3. Expose to cold ultra-violet lights for periods of 24, 48, 96, 192 hours.
4. When preliminary work has been completed using any of the above methods, it is suggested that a series of panels be sent to Florida for exposure of 3, 7, 14, and 21 days.

Discussion

F. H. Thomas (Sherwin–Williams Co.): What woods did you use in your tests?

Mr. Lubeck: Walnut, mahogany, oak, prima vera, avodire, and maple were used.

J. B. Box (Box Planing Mill and Store Fixture Co.): When using walnut or mahogany color on maple and birch and using a toner, what is the best time to apply the toner?

Mr. Lubeck: Toners often have fugitive dyes which will fade regardless of when applied. Pigments are more permanent and give more protection as the opaqueness increases. Darkening of the above woods may offset fading of stains if stains are more convenient to use.

R. I. Quigley (The Lilly Company): Did the carbon arc give better results than the mercury vapor lamp? Our results show that the carbon arc is more nearly like sunlight.

Mr. Lubeck: The carbon arc was superior. The mercury vapor lamp gives a yellowish discoloration, while sunlight produces an orange color, but

it does give a good indication for lacquer or contaminants; however, it is poor for other conditions such as stains.

W. E. Martin (Grand Rapids Varnish Co.): With clear films, did the initial exposure results change or develop if panels were reviewed six months later?

Mr. Lubeck: Yes, the degree of yellowing increased after exposure.

Mr. Martin: Have you tested non-staining rubbing oils?

Mr. Quigley: We have a method for testing the staining of rubbing oils. When they are applied to a surface and observed under ultra-violet light, oils that will stain, fluoresce.

Mr. Martin: Are some petroleum oils non-staining?

Mr. Quigley: Some are superior to others. Some have excellent non-staining qualities.

Mr. Lubeck: If the oils fluoresce, they will stain lacquer.

Mr. Selby (E. I. du Pont de Nemours Co.): We have found fluorescent lamps better than the carbon arc. High temperatures under the arc may show an effect from heat.

Mr. Lubeck: Thermocouples under face veneers showed a maximum of 212° with the carbon arc. Temperatures exceeding 180° were found in actual sunlight conditions so the effect of heat cannot be discounted.

Mr. Box: Have you made any tests using distilled water for rubbing?

Mr. Lubeck: It is harmless in its effect on discoloration, but it wets the wood. Soybean oil does not tend to produce discoloration.

Transverse Shrinkage of Red Oak and Beech[1]

D. C. McINTOSH[2]

Discusses the results of tests to determine effects of the structure of wood on the anistropic shrinkage of red oak and beech. Particular attention has been given to the shrinkage of rays and their effect in reducing the radial shrinkage of wood in view of the fact that some recent investigators have rejected the ray restraint theory.

Introduction

THIS ARTICLE, the fourth and final in a series, discusses the results of tests conducted at the Ottawa Laboratory of the Forest Products Laboratories of Canada, to determine effects of the structure of wood on the anisotropic shrinkage of red oak and beech. Particular attention has been paid to the shrinkage of rays and their effect in reducing the radial shrinkage of wood in view of the fact that some recent investigators have rejected the ray restraint theory.

Discussion of Results

A. Shrinkage of Rays: Experimental results presented in previous articles (16, 17, 18) have shown that the radial shrinkage of broad rays of red oak is 2.59 per cent compared to 4.83 per cent for wood (vertical cells and fine rays) surrounding the broad rays. Similarly with beech, the radial shrinkage of broad rays was determined to be 2.32 per cent, while the radial shrinkage of the surrounding wood, free of broad rays, was 6.73 per cent. Photomicrographs of the distortions that developed in the drying of transverse sections from which broad rays had been partially isolated were employed to illustrate the difference between the radial shrinkage of the broad rays and that of the surrounding wood. Narrow transverse sections, isolated with a broad ray along one radial edge, never failed to curve on drying so that the broad ray was on the convex edge.

Curvatures of small fragments of transverse sections of red oak and beech, isolated so as to contain a fine ray at or near one radial edge, have indicated that the fine rays also shrink less in a radial direction than do the longitudinal cells surrounding them. It is therefore reasonable to believe that the fine rays possess a shrinkage potential in a radial direction which is similar to that of broad ray tissue.

The volume of wood occupied by broad rays was estimated at 10 per cent for red oak and 6 per cent for beech. The volume of wood (free of broad rays) occupied by fine rays was determined as about 14 per cent for red oak and 16 per cent for beech. Therefore, it was calculated that ray tissue occupied approximately 23 per cent of the wood of red oak and about 21 per cent of the wood of beech. These results compare fairly well with those published by Myer (20) who determined the average ray content of red oak at 21.2 per cent and of beech at 20.4 per cent. The variation in results apparent in comparing the values obtained in both studies can probably be attributed to the variations in ray volume normally found in different samples of wood of the same species.

The experimental measurement data, obtained from tests to determine the effect of various proportions of ray tissue present in transverse sections of red oak and beech upon the radial shrinkage of the sections, have shown the significant effect of rays in restraining the shrinkage of wood in a radial direction. If the curves illustrating relationship between radial shrinkage and the volume occupied by rays be extrapolated to zero ray volume, it appears that the theoretical radial shrinkage for red oak transverse sections free of ray tissue is about 6.2 per cent while that for transverse sections of beech without rays is about 11.7 per cent. As was previously indicated, extrapolation of the curves is rather difficult because of their slope in the neighborhood of 14 per cent ray volume in red oak and 16 per cent ray volume in beech.

The theoretical radial shrinkage values for wood of red oak and beech without rays (6.8 per cent and 11.7 per cent, respectively), resulting from substitution of experimental data in the Pentoney equation (18) agree closely with values determined from extrapolation of these curves. The curves obtained by substitution of experimental data into equation 2 of the derivation show close agreement with the plotted experimental results. Probable causes of the deviations from

[1] A contribution of the Ottawa Laboratory, Forest Products Laboratories of Canada, Forestry Branch, Department of Northern Affairs and National Resources, Ottawa, Canada.

[2] This article essentially is part of a thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Wood Technology, State University of New York College of Forestry at Syracuse.

[3] Numbers in parentheses refer to literature cited.

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exact agreement are the errors in determining the exact volume of ray tissue contained in the test specimens, and the structure of wood adjacent to the broad rays.

Since it was calculated that the ratio E_o (i.e., $\frac{E_w}{E_r}$) for red oak is 0.181 and for beech, 0.124, it follows that in the radial direction the modulus of elasticity of the rays (E_r) of oak is 5.5 times the modulus of elasticity of "rayless" wood (E_w) of oak, while E_r is equal to about 8.1 E_w for beech. Therefore, since the rays are considerably stronger radially than the longitudinal cells, it would be expected that, for normal wood, the modulus of elasticity in the radial direction should be greater than the modulus of elasticity in the tangential direction. This is in agreement with the results published by Hearmon (11) in which it is shown that the modulus of elasticity in the radial direction in oak and beech is about two or more times the modulus of elasticity in the tangential direction. Wangaard (25) also notes that the modulus of elasticity of different species is consistently greater radially than tangentially.

Reference is made to the work of Barkas (2) in which the theoretical percentage of rays was calculated from the modulus of elasticity in the radial and tangential directions for wood of different species on the assumption that the rays are as strong along their axes as the longitudinal cells along their axes. When the theoretical values for the volume of wood occupied by rays are compared to measured ray volume, Barkas indicates that the difference between the two sets of values could be explained if the rays were weaker in their longitudinal direction than the fibers in the direction parallel to the grain.

Data presented by Hearmon (11) indicate that the ratio of the modulus of elasticity in the longitudinal direction to that in the tangential direction is approximately 5.5 for oak and 12 for beech. Kollman (13), on the other hand, reports that the ratio is about 11 for oak and 12 for beech. Owing to the lack of strength data on species and material used in the shrinkage tests reported herein, a true $\frac{E_L}{E_T}$ ratio cannot be applied. However, a ratio of 10 was arbitrarily chosen as reasonable for both species for the purpose of the following calculations, where:

E_r = Modulus of elasticity of the rays in the direction of their longitudinal axes (i.e., radially in the wood).

E_{wl} = Modulus of elasticity of "rayless" wood in the direction perpendicular to the longitudinal axis of the cells.

E_{wll} = Modulus of elasticity of "rayless" wood in the direction parallel to the longitudinal axis of the cells.

For red oak

$$\frac{E_r}{E_{wl}} = 5.5$$

$$E_r = (5.5)\ (E_{wl}) = \frac{5.5}{10}\ (E_{wll})$$

$$= 0.55\ (E_{wll})$$

For beech

$$\frac{E_r}{E_{wl}} = 8.1$$

$$E_r = (8.1)(E_{wl}) = \frac{8.1}{10}\ (E_{wll})$$

$$= 0.81(E_{wll})$$

These results support the suggestion of Barkas that the rays are weaker in their longitudinal direction than the longitudinal cells in a direction parallel to their longitudinal axes.

There is a possibility that the strain in the rays and in the wood undergoing shrinkage may be in excess of their proportional limits. However, in the case of the wood, cell deformation in the radial direction may prevent the proportional limit from being exceeded. Observations of the change in shape of the vessels in red oak near broad rays indicate that the rays are responsible for some radial extension of the vessels adjacent to broad rays during drying. The fact that the vessels some distance from the broad rays always shrink tangentially but only a small amount radially or may even increase in radial dimension while drying, might be taken as indication that the wood accommodates by deforming somewhat under the stress exerted by the fine rays. This is supported also by the high T/R ratio of the springwood compared to the summerwood in both oak and beech (18).

The small transverse sections isolated with a broad ray on one radial edge, which curve on drying, always straighten to their original shape when resoaked. This appears to indicate that the proportional limit has not been surpassed in such specimens. The situation may, of course, be different where a transverse section is composed of a broad ray with fibrous wood on both sides of the ray, so that the broad ray and the fibrous wood are prevented from accommodating to drying stresses by curving.

Test results have indicated that the longitudinal shrinkage (parallel to the grain of the wood) of broad ray tissue is 3.41 per cent for red oak and 5.69 per cent for beech. The longitudinal shrinkage of tangential sections of red oak and beech without broad rays was found to be about 0.30 per cent. The tangential shrinkage observed in this study on broad rays of red oak—isolated from tangential sections—is approximately 9.0 per cent. Similar measurements of the shrinkage of broad rays of beech were not attempted because of the small tangential width of the rays.

Vodoz (24), in his article on the shrinkage and swelling of wood, refers to tests conducted by Perelygin on samples of oak wood with the following results: Tangential shrinkage of the blocks with large rays included was 10.7 per cent, tangential shrinkage of wood between the large rays was 8.7 per cent, while broad rays shrank 23.6 per cent tangentially. Study of the anatomical basis of shrinkage should be particularly rewarding in such oak as this value reportedly obtained by Perelygin for tangential shrinkage of broad ray tissue is, of course, much larger than the 9.0 per cent observed in the present study.

It is probable that under certain conditions broad rays tend to shrink more tangentially in solid wood than when isolated because of the restriction imposed in the longitudinal direction by vertical wood cells. However, the relatively high radial shrinkage of the vertical cells acting to increase the radial shrinkage of the rays in solid wood might reduce the apparent tangential shrinkage of non-isolated rays.

There is a possibility that relatively high longitudinal shrinkage of rays might contribute to longitudinal shrinkage of the wood—especially of low-density wood. This latter condition, however, may not be in effect because of the fact that the stress between the rays and the vertical cells is applied in the direction in which the strength of the rays is expected to be low whereas that of the vertical tissue is high.

The results with regard to the longitudinal (parallel to the grain of the wood) and radial shrinkage of ray tissue and the effect of rays on restraining the radial shrinkage of wood agree in principle with those of Barkas (1, 2), Clarke (4), Greenhill (7, 8, 9) and Lindsay and Chalk (14). They are, however, in opposition to information and opinions published by Kollman (13), and Ritter and Mitchell (22, 23).

Wardrop and Dadswell (26) have shown that the micellar angle of the secondary wall of ray cells investigated varied between 30 and 50° with respect to the longitudinal axis of the ray cells. Ritter and Mitchell (23),

on the other hand, report an arrangement of fibrils in ray cells "approximately in the vertical crosswise direction of the ray cells, which is the longitudinal direction of the wood". Omitting influence of other probable factors, an orientation of the type reported by Ritter would be expected to cause the greatest shrinkage of the rays in the radial direction and a lack of shrinkage in the vertical direction (as described by Ritter and Mitchell, "swelling" is used in place of "shrinkage" (22)). This is contradictory to the measurement data obtained from investigations described in this series of articles, the results of which would tend more to support the findings of Wardrop and Dadswell.

If the fibrils within the ray cells are at a slope of something less than 45° measured from the longitudinal axis of the ray cells, the difference between the radial and longitudinal shrinkage of the rays (2.59 per cent and 3.41 per cent, respectively for red oak, and 2.32 per cent and 5.69 per cent for beech) is readily understood. However, if a uniform spiral arrangement of the fibrils exists in the walls of ray cells, it is difficult to explain the large difference between the tangential and longitudinal shrinkage (9.0 per cent and 3.41 per cent, respectively) obtained for broad rays of red oak on the basis of the fibrillar orientation alone.

Investigations reported by Harlow and Wise (10) have shown that the broad rays of *Casuarina inophloia* F. Muell and Bailey, and *Quercus alba* L. are higher in lignin content and lower in cellulose than the total wood. In the article, photomicrographs of a tangential section of a broad ray and a transverse section of the summerwood of white oak after treatment with 72 per cent sulphuric acid show that the middle lamella is thicker in the ray than in the fiber-tracheid tissue while the secondary wall is thinnest in the ray. Since the chemical composition of broad ray tissue in red oak may differ appreciably from that of the vertical tissue, the different shrinkage characteristics of the broad rays compared to those of the vertical cells might be expected to be different regardless of the fibrillar orientation.

Reference is made to the hypothesis published by Frey–Wyssling (5, 6) in which the major cause of differential shrinkage is attributed to the middle lamella. The possibility was considered that the difference in amount of middle lamella substance in the longitudinal and tangential directions within the broad rays might be a factor contributing to the difference in shrinkage in the two respective directions. However, it was impossible without undertaking an entirely new investigation to determine the variation in the amount of middle lamella in the three primary directions within the rays.

Preliminary measurements on temporary mounts of tangential sections cut from untreated green red oak have indicated only a slightly larger number of cells per unit length in the tangential than longitudinal directions. These measurements, of course, were hindered by the irregularity of placement of ray cells and the variation in distribution of ray cells of different size classes. Although there may be a difference in the amount of middle lamella lying between the ray cells as measured longitudinally and tangentially, it is difficult to suppose that this difference can account for such a difference in shrinkage in the longitudinal and tangential directions in broad rays of red oak. Furthermore, the radial length of ray cells is in general much greater than either the tangential or longitudinal dimensions.

If the Frey–Wyssling hypothesis is applicable, and if the amount of middle lamella surrounding the ray cells is reasonably uniform in thickness, it would be expected that the similarity in shrinkage of rays of red oak would be in the longitudinal (3.41 per cent) and the tangential (9.0 per cent) rather than in the longitudinal (3.41 per cent) and radial (2.59 per cent) directions.

There is a possibility that the molecular structure of the cellulose in ray cells may differ from that in the cell walls of vertical cells. Kitao (12) from investigations on birch *(Betula Tauschii* Koidz.) reports that "the gelatinous nature of the cell wall together with the low viscosity, appeared to indicate the low polymerization degree of the ray-cell-cellulose of the birch studied". Cellulose of a low degree of polymerization could possibly have characteristic shrinkage properties.

The statement, published by Ritter and Mitchell (23), that the "ray cells may be omitted from among the various factors that cause less radial than tangential shrinkage of wood" was previously quoted. This conclusion was based upon: (a) illustrations of optical effects of polarized light visible in chemically treated wood and ray cells; (b) observations of the drying of radial sections with ray cells on one face and fibers on the other face (". . . . some of the sections dried straight, some bowed slightly toward the ray-cell face, and some bowed toward the fiber face . . . .", however, the authors did not report investigating the reason for bowing); (c) shrinkage of isolated, "delignified" ray cells which was reported to be approximately the same as that of wood from which they were isolated; (d) radial shrinkage of pine blocks "from which ray cells had been removed by special degradative action", but the technique was not explained; and (e) reference to tests in which it was found "that heat was transferred at slightly slower speed radially than tangentially".

It is significant to observe that in three of the tests cited above (a, c, and d), Ritter and Mitchell worked with chemically treated or degraded wood and, in some cases, with isolated cells attacked by chemicals in such a way as to leave only the cellulose skeleton of the original. If the results of test (c) above can be applied to red oak and beech, delignified ray cells should show a greater radial shrinkage than untreated rays reported herein. Although isolated cells probably have greater dimensional change properties than tissues composed of similar cells, the comparison could be interpreted as contrary to the Frey–Wyssling theory that the source of the problem lies with the middle lamella.

It is of interest to note here that investigations by Matsumoto (15) have not confirmed Frey–Wyssling's theory on the effect of the middle lamella on the anisotropic shrinkage of wood. The summary by Matsumoto states in part that "it was found that in lignified wood, most of the middle lamella is a lignin substance and that swelling and shrinking take place not there but in the secondary layer of the cell wall." It is hoped that other investigations can be designed to test further the validity of Frey–Wyssling's hypothesis.

There can be no doubt, however, but that rays in species investigated in this study (red oak and beech) not only shrink much less radially than does the fibrous wood surrounding them, but that rays also play an important part in restricting the radial shrinkage of wood. Under the heading "Tangential–Radial Shrinkage Ratios For Transverse Sections" of this report, the effect of rays on the differential shrinkage of wood will receive further comment.

B. Tangential Shrinkage of Springwood and Summerwood: 1. Red Oak—From observations of results showing the tangential shrinkage of isolated springwood (5.10 per cent), isolated summerwood (8.37 per cent), and non-isolated springwood and summerwood shrinking together (7.60 per cent), it appears that the tangential shrinkage of wood of red oak is influenced to a great extent by the large tangential shrinkage of the dense summerwood.

In the interaction of the springwood-summerwood tangential shrinkage, the springwood shrinkage is increased by 49 per cent by the large shrinkage of the summerwood (5.10 per cent to 7.60 per cent) while the summerwood shrinkage is decreased about 9 per cent (8.37 per cent to 7.60 per cent) due to the influence of the springwood. The tangential shrinkage of transverse sections of red oak as measured in these experiments thus approaches the tangential shrinkage of isolated summerwood.

Fig. 1 shows the end-surface checking in a small block of red oak. The block, in water-saturated condition, was cut smooth on its transverse surface by means of a microtome and placed in an oven, equipped with forced air circulation, at 103° C. in order to produce surface checks. The block was removed from the oven after 20 minutes' drying and the end surface was photographed. It will be noted that the visible checks occur in the summerwood, the region of the annual ring of red oak which shows the greatest tangential shrinkage.

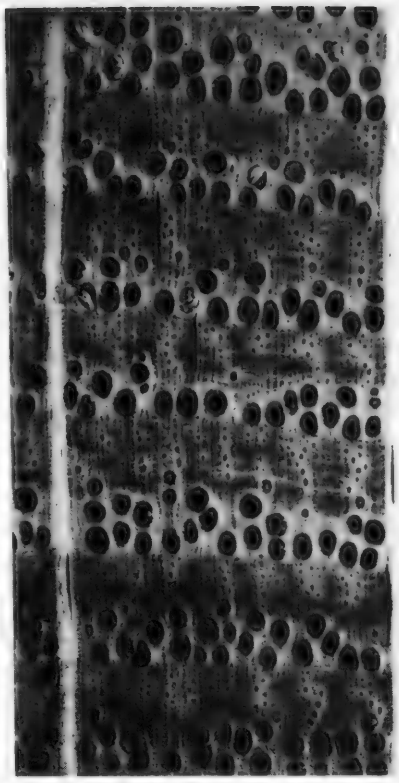

Fig. 1.—Red oak, initial stage of checking on end surface of moist wood after 20 minutes exposure at 103° C. Magnified.

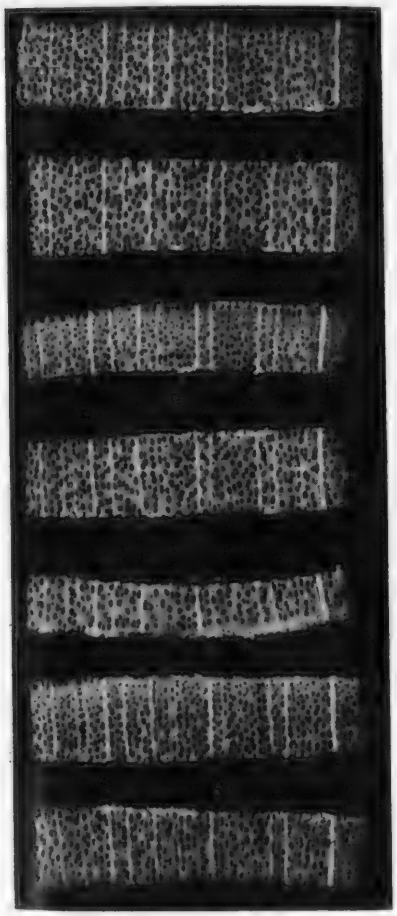

Fig. 2.—Beech transverse section (80 microns thick), dissected wet and subsequently dried under indoor atmospheric conditions. Components are in same relative position as in original section, showing distortion apparently because the last-formed summerwood exhibited slightly less tangential shrinkage than the neighboring wood. Magnified.

2. Beech: Measurements of the tangential shrinkage of isolated springwood and summerwood of beech show that the tangential shrinkage of the springwood formed early in the growing season is greater than that of later springwood located about half-way through the annual ring (12.00 per cent and 11.32 per cent, respectively). Furthermore, measurements have shown that the tangential shrinkage of the dense summerwood is less than that of the springwood (10.71 per cent compared to 12.00 per cent and 11.32 per cent). These results were, of course, unexpected and the reverse of the situation found with red oak or as depicted in Pentoney's work with Douglas-fir (21).

Several transverse sections free of broad rays were dissected tangentially so that summerwood was present along one tangential edge of the specimens. On drying, curvature of the specimens resulted with the summerwood always on the convex edge. This type of deformation is illustrated in Fig. 2, a photograph of portions of beech, 80 microns in thickness, which contained about three annual rings. Different portions of the section were separated by means of a scalpel while the section was in the water-saturated condition. The photo shows the specimens, dried under normal laboratory atmospheric conditions, arranged in the same relative position in which they composed the original section. The curvature of the specimens, caused by the greater tangential shrinkage of the apparently light-weight springwood as compared to that of denser wood formed late in the growing season, can be observed.

Fig. 3 shows drying checks on the end surface of a block of beech. The block, before undergoing shrinkage, was surfaced by means of a microtome, then dried in an oven at 103° C. in the same manner as the block of red oak illustrated in Fig. 1. The photomicrograph shows that the end-surface checks in beech are rather evenly distributed in both springwood and summerwood, indicating that the springwood shrinks at least as much tangentially as the summerwood.

Additional tests of other samples of beech would be valuable in determining if the tangential shrinkage of the springwood is always at least as great as that of the summerwood. It would appear that an investigation as to the cause of the unexpected results, involving measurement of the fiber saturation point of both springwood and summerwood and critical study of cell wall organization might prove to be a rewarding approach to appreciation of the physical basis of dimensional changes.

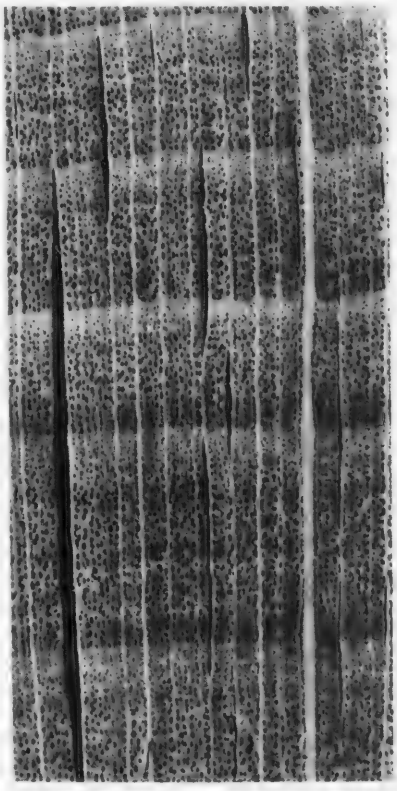

Fig. 3.—Beech, showing drying checks on end surface of small block. Magnified. Compare with red oak, Fig. 1.

Table 1.—T/R SHRINKAGE RATIOS FOR SPRINGWOOD AND SUMMERWOOD OF RED OAK

Material	Tangential Shrinkage %	Radial Shrinkage %	T/R Ratio
Isolated Springwood	5.10	2.58	1.98
Isolated Summerwood	8.37	8.14	1.03

Table 2.—T/R SHRINKAGE RATIOS FOR SPRINGWOOD AND SUMMERWOOD OF BEECH

Material	Tangential Shrinkage %	Radial Shrinkage %	T/R Ratio
Isolated Springwood			
(i) Early	12.00	5.71	2.10
(ii) Half-way through annual ring	11.32	5.71	1.98
Isolated Summerwood	10.71	9.8*	1.09

*Calculated value.

C. Radial Shrinkage of Springwood and Summerwood: 1. Red Oak—Observation of the results cited for red oak (18) indicates that the radial shrinkage of isolated summerwood is about three times greater than the radial shrinkage of isolated springwood (8.14 per cent and 2.58 per cent, respectively). It is of special interest to note that radial shrinkage values for non-isolated springwood (2.09 per cent) and non-isolated summerwood (6.34 per cent), measured in transverse sections from which broad rays had been separated, are less than the corresponding shrinkage results for isolated springwood and summerwood. In both sets of measurements, however, the ratios of radial shrinkage of summerwood to that of springwood are similar (slightly greater than three).

From observation of transverse sections of red oak used in the test, it appears that the springwood-summerwood volume proportion is approximately 2:3. When the radial shrinkage of non-isolated springwood (2.09 per cent) and summerwood (6.34 per cent) are weighted and averaged according to the relative proportions of wood occupied by each, the result is a total radial shrinkage of 4.64 per cent which approaches the observed radial shrinkage of 4.83 per cent for wood sections free of broad rays. This supports the observation that summerwood radial shrinkage may be closer to 6.34 per cent than 8.14 per cent. The results are in agreement with the Morath observation that the radial shrinkage of wood is an average of the springwood and summerwood shrinkage in a radial direction.

2. Beech: It was determined that the radial shrinkage of isolated springwood (about 75 per cent of the annual ring) of beech is 5.71 per cent while the radial shrinkage of springwood and summerwood shrinking together, measured over a number of neighboring annual rings, is 6.73 per cent. From these results, it was calculated that the radial shrinkage of isolated summerwood of beech should be in the neighborhood of 9.8 per cent. It was found necessary to use this calculated value for the radial shrinkage of summerwood because measurement of the radial shrinkage of the small isolated summerwood specimens was not feasible with the technique employed in the present study.

D. Tangential-Radial Shrinkage Ratios for Springwood and Summerwood: As cited in Table 1, the calculated T/R ratio obtained from experimental data for red oak was found to be 1.98 for isolated springwood and 1.03 for isolated summerwood.

The irregularity of arrangement of vessels in the springwood of red oak and the variation in the amount of fibrous material surrounding the springwood vessels make it difficult to distinguish for purposes of measurement a satisfactorily definable boundary between springwood and summerwood within the annual layer. While the large T/R ratio for isolated springwood may be due in part to the difference in amount of wood material in the radial and tangential directions, observation of the specimens failed to disclose any major difference. It is probable that the large T/R ratio for springwood of red oak may be partly the result of the resraining effect of the fine rays in the radial direction in isolated springwood. This radial restraint might also indirectly increase the tangential shrinkage values over those that might be expected if no such restraint were present. Because the dense summerwood is comparatively high in strength, it is probable that the fine rays do not as effectively restrain the shrinkage of the summerwood in the radial direction.

Table 2 shows the T/R ratios for isolated springwood and summerwood of beech. Both T/R ratios for springwood are based on a radial shrinkage value of 5.71 per cent for isolated springwood (75 per cent of the annual ring) since, due to the difficulties of isolation and measurement, no radial shrinkage values were determined for different portions of the springwood. The radial shrinkage of isolated summerwood is a calculated value as previously described.

As shown in Table 2, the T/R ratio for isolated springwood of beech is about two, while that for isolated summerwood is about one. It is of interest to note the similarity of the T/R ratios for isolated springwood of red oak and beech and for isolated summerwood of the two species. As proposed for red oak, the restraining effect of the fine rays on the radial shrinkage of isolated springwood of beech may be of importance in producing a T/R ratio of two for springwood. The radial restraint imposed by the fine rays may also tend to augment the tangential shrinkage beyond that which might be expected if no such radial restraint were present. As with red oak, the low T/R ratio of summerwood might be explained by the fact that the dense, and therefore relatively strong, summerwood does not allow the ray cells to exert their full effect in restraining radial shrinkage.

Reference is made to data published by Kollman (13) in which the T/R ratio in swelling (sic) of woods of different densities is shown to decrease as the density increases. Kollman rejects the ray restraint theory since he observes that the rays are poorly developed in light-weight woods and are very strongly developed in woods with high specific gravity. He indicates, therefore, that if the ray restraint theory is applicable, an increase in T/R ratio with increased density should result instead of the opposite. It could be said, however, that Kollman's data indicates rather that the trend of increase in T/R ratio with decrease in density is caused by the fact that the influence of the dimensional change characteristics of the rays in the radial direction is increasingly more effective as the density and, therefore, the strength, of the wood decreases. The large difference in the T/R ratios of springwood and summerwood compared to their relative apparent densities in both red oak and beech would tend to support this latter interpretation.

E. Tangential-Radial Shrinkage Ratios for Transverse Sections: 1. Red Oak—Table 3 has been prepared to show several calculated T/R shrinkage ratios for red oak determined from radial shrinkage data. The ratios in Table 3 were calculated on a basis of a tangential shrinkage of 7.6 per cent, a value determined for springwood and summerwood of red oak shrinking together, which takes into account the shrinkage interaction effect of the two portions of the annual ring in the tangential direction.

Table 3.—T/R SHRINKAGE RATIOS FOR TRANSVERSE SECTIONS OF RED OAK

Material and Conditions of Measurement	Radial Shrinkage %	T/R Ratio*
Transverse sections with all rays included	4.10	1.85
Transverse sections with only fine rays included	4.83	1.57
Transverse sections—no ray tissue† —from extrapolation of curve	6.2	1.23
—from equation	6.8	1.12

*Based on tangential shrinkage of 7.6 per cent for springwood and summerwood between broad rays, shrinking together.
†Described in text of previous reports.

Table 4.—T/R SHRINKAGE RATIOS FOR TRANSVERSE SECTIONS OF BEECH

Material and Conditions of Measurement	Radial Shrinkage %	T/R Ratio*
Transverse sections with all rays included	5.92	1.96
Transverse sections with only fine rays included	6.73	1.73
Transverse sections—no ray tissue† —from extrapolation of curve	11.7	1.0 (approx.)
—from equation	12.7	0.91

*Based on a tangential shrinkage of 11.62 per cent for undissected springwood and summerwood.
†Described in text of previous reports.

Although the radial and tangential shrinkage values for sections with broad rays included (4.10 per cent and 7.6 per cent, respectively) are larger than corresponding values for red oak published by the Forest Products Laboratories of Canada (3) from tests on standard small clear specimens, the T/R ratios are the same (1.85 compared to 1.86).

Results in Table 3 indicate that when broad rays are excluded from transverse sections of red oak, the T/R ratio is reduced from 1.85 to 1.57. It is therefore shown that, in the transverse sections of red oak studied, broad rays appear to account for about 33 per cent of the T/R ratio above unity. If it is assumed that the value of 6.2 per cent is correct for radial shrinkage of "rayless" wood, obtained from extrapolation of the curve indicating the relationship between radial shrinkage of transverse sections and the proportion of the sections occupied by ray tissue, then the T/R ratio for sections free of all rays is reduced to 1.23. In this instance, the presence of ray tissue (both fine and broad rays) accounts for 73 per cent of the T/R ratio above unity. By substraction, therefore, it may be determined that fine ray tissue appears to account for 40 per cent of the T/R ratio above 1.

It must be noted here that the relative importance of broad and fine rays in reducing the radial shrinkage and the resulting T/R ratios of the sections of red oak depends upon the technique employed and the shape of the curves relating radial shrinkage to the proportion of the sections occupied by ray tissue. In this sense it has been argued that, were it possible to eliminate first the effect of the fine rays, it is probable that the broad rays would appear the more important in restricting radial shrinkage.

If the assumption is true that 73 per cent of the T/R ratio above unity is due to the influence of ray cells in restraining the radial shrinkage of transverse sections, the remainder (27 per cent) might be accounted for by the influence of the springwood-summerwood interaction in a radial direction (Morath theory) and possibly other factors.

Using the radial shrinkage value of 6.8 per cent obtained from the equation for transverse sections without ray tissue, the effect of the rays on decreasing the T/R ratio is shown to be greater than when the extrapolated value is used. In this instance, the T/R ratio for wood with no rays is 1.12 which indicates that ray tissue accounts for 86 per cent of the T/R ratio above unity.

2. Beech: Tangential-radial shrinkage ratios calculated for transverse sections of beech are presented in Table 4. The ratios in Table 4 were determined on the basis of a tangential shrinkage of 11.62 per cent for undissected springwood and summerwood shrinking between broad rays in relatively wide transverse sections of beech.

Although the radial and tangential shrinkage values of transverse sections of beech with broad rays included (5.92 per cent and 11.62 per cent) are larger than corresponding values for beech published by the Forest Products Laboratories of Canada (5.2 per cent and 10.2 per cent) from tests on small clear specimens (3) the T/R ratios of 1.96 are the same. This agreement in T/R ratios from transverse sections and from small clear specimens was also found in red oak.

When broad rays are excluded from transverse sections of beech, the T/R ratio is reduced from 1.96 to 1.73. It appears, therefore, that broad rays account for about 24 per cent of the T/R ratio above unity. As with similar calculations for red oak, the determination of the relative importance of the broad rays and fine rays in reducing the T/R ratios in beech depends upon the experimental technique. If the effect of the fine rays could have been eliminated first, the broad rays would probably have appeared to be of much greater relative importance.

On the assumption that the value of 11.7 per cent for the radial shrinkage of rayless wood, obtained from the extrapolation of the curve indicating the relationship between radial shrinkage of transverse sections and the proportion of the sections occupied by ray tissue, is correct, the T/R ratio for wood without rays is reduced to about 1.0. This indicates that the presence of ray tissue (broad and fine rays) may account for the total T/R ratio above unity. The T/R ratio calculated from the radial shrinkage of "rayless" wood obtained from the equation indicates that without rays, the radial shrinkage of beech would be slightly greater than the tangential shrinkage.

Consideration of the similarity in amount of tangential shrinkage of isolated springwood and summerwood of beech indicates that the Morath effect (the interaction of shrinkage of springwood and summerwood) in the tangential direction is almost negligible.

The fact that radial shrinkage of wood of beech is less than the tangential shrinkage appears to be accounted for by the radial restraint caused by the broad rays and by the fact that, in wood between broad rays, the radial shrinkage of springwood is less than that of the summerwood. This latter cause could be described superficially as the Morath effect in the radial direction. Fundamentally, however, considering the T/R ratios of springwood and summerwood and the shrinkage of sections with different proportions of ray tissue, it is proposed that the apparent Morath mechanism in beech is, in effect, largely the result of the restraint in radial shrinkage imposed by the rays in the springwood regions.

It is to be noted that in calculation of the T/R shrinkage ratios for transverse sections of red oak and beech as cited in Tables 3 and 4, the tangential shrinkage is based on the measured shrinkage of springwood and summerwood, shrinking together, between broad rays. The T/R ratios for transverse sections with all rays included does not take into account the tangential shrinkage of the broad rays, which for red oak was found to be slightly greater than the tangential shrinkage of isolated summerwood. Since broad rays possess a relatively large tangential shrinkage, it is

reasonable to expect that fine rays also have an appreciable tangential shrinkage.

The T/R ratios for transverse sections with no ray tissue are, of course, calculated by using tangential shrinkage values for sections with fine rays included. If it were possible to measure the tangential shrinkage of sections without any ray tissue, the use of this value in determining the T/R ratios for wood without rays might reduce the T/R ratios for rayless wood significantly.

Observations of the shrinkage of balsa *(Ochroma lagopus* Sw.) made by Wiepking and Doyle (27) are of interest. Their results show a range in tangential shrinkage of 3.4 per cent to 7.0 per cent and in radial shrinkage of 1.4 per cent to 2.1 per cent, a T/R ratio of well over 2. Balsa is a species in which annual rings are absent or indistinct but in which the rays are conspicuous. For this reason it may be stated that in balsa the Morath effect probably is not in operation to produce anisotropic shrinkage in the transverse plane. An obvious explanation of the differential transverse shrinkage of balsa may lie in the probable restraint in the radial direction caused by the ray cells in such a light-weight wood of low strength although other factors related to the submicroscopic structure of the cell walls may be in effect.

Exploratory tests by the author, in which the drying behavior of transverse sections of sugar maple *(Acer saccharum* Marsh.) and sycamore *(Platanus occidentalis* L.) has been observed, have indicated that the broad rays of these two species also shrink less in the radial direction than the wood surrounding them. Portions of the transverse sections, which were isolated so that a broad ray was present along one radial edge, curved in drying in a manner similar to sections of red oak and beech. Preliminary observation of deformations in permanent mounts of transverse sections of several coniferous species have also suggested that the rays shrink less radially than the tracheids.

The differential shrinkage observed within the broad rays of red oak and beech is of interest in the light of the observations made by other investigators as to the orientation of the fibrils within the ray cell walls. It is hoped that attempts can be made to investigate the orientation of the fibrils in ray cells of red oak and beech and to determine the effect of the orientation on the differential shrinkage of the rays.

Summary

Measurements have shown that broad and fine rays of red oak and beech shrink much less radially than the vertical tissue and restrict the radial shrinkage of the wood.

Extrapolation of the relationship between the radial shrinkage of transverse sections of red oak and beech and the relative proportion of the sections occupied by ray tissue suggests that the rays are responsible for most of the difference between radial and tangential shrinkage. This is verified by substitution of measurement data into an equation derived mathematically to obtain the radial shrinkage of "rayless" wood.

Measurement in red oak and beech of radial and tangential shrinkage of springwood and summerwood without broad rays has indicated a tangential-radial shrinkage ratio for springwood of about 2 while that for summerwood is about 1. It is suggested that the fine ray tissue is responsible for the large T/R ratio of the relatively weak springwood.

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Does the General Forestry Curriculum Satisfy the Training Needs of the Forest Products Industry?[1]

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Points out how various courses offered in general forestry curricula are adequate for some kinds of employment offered by forest products industries. Survey of graduates reveals that such training provides a foundation which can be successfully adapted to the wood products field. Specific courses are evaluated in relation to the needs of employers.

IN THIS ERA OF MASS PRODUCTION and specialization in industry, each job seems to become more specialized as time goes on and machines and processes are modified for more efficient production. It seems, also, that the number of kinds of special jobs multiplies. This may increase the efficiency of industry, but it creates a problem for the schools. They are called upon to turn out men for each kind of job, trained to fit into that position with a minimum of help from industry.

Since a great many employers demand a high degree of technical skill and knowledge in a new employee, high schools and institutions of higher education have established specialized courses of study and practice for the different major fields of industry in general. Also, where the demand is great enough, they have set up highly specialized curricula to serve a specific industry or even a single phase of such an industry. The general forestry curriculum may be classed with these highly specialized curricula, since service to certain phases of forest products industry is among its purposes.

The question, therefore, of whether or not the general forestry school curriculum produces men adequately trained for forest products industries cannot be given a direct yes or no answer. Certainly their training is adequate for some of the many and diverse kinds of employment offered by industry. For others it just as certainly is not. Of course, it is not possible for any single course of study to cover fully such a wide field. No single curriculum can possibly impart the variety of technical knowledge and skills required in such diverse occupations as timber growing and protection, harvesting raw forest products, purchasing of raw materials for the mill, supervision of production, quality control, research and development, sale of products, and finally the over-all management of business. No college would attempt to perfect men in all the knowledge and techniques related to these varied positions in any single curriculum, to say nothing of the cultural background expected in a college-trained man.

The general forestry school directs its main effort toward training men in the management of forest lands and the production of raw materials from the forests. Its chief service to industry lies in these fields and the majority of its graduates find employment in them. It does not attempt to compete with those schools offering appropriate special curricula in producing men trained for the manufacturing, research and development, distribution, or business administration phases of forest products industry.

A survey of the employment situation, however, will find a large number of graduates of general forestry curricula successfully serving industry in positions for which they were not specifically trained as undergraduates. Some of these men are in high executive positions; some in highly technical work such as quality control, research, or development; some are directly concerned with production, and still others are in sales work at all levels.

A recent survey of employment of all University of Maine forestry graduates shows that approximately 12.5 per cent are employed in forestry industry work other than that directly related to the forest. Of these, 51 per cent are engaged in manufacturing, 37 per cent in distribution, 4 per cent in research, 2.5 per cent in teaching in the forest products field, and 5.5 per cent miscellaneous and unclassified.

In searching for reasons for this situation, we find a variety of answers. Some students enter forestry schools whose primary interest lies in forest products rather than in the forest. These men are unable to attend an institution offering special curricula in forest products and enter forestry schools as the best alternative. Others discover as they progress in their studies and as they gain experience through summer employment that products work is more to their liking than forest management, but are unwilling or unable to change to another school. Still others enter products work upon graduation because of chance employment opportunities. A few marry into a business. Other reasons undoubtedly exist.

Evidently the training of these men has at least given them a satisfactory foundation upon which they have based their successful adaptation. Examining their basic education in the forestry school reveals training in the fundamental sciences of mathematics, physics, chemistry, botany, and zoology. It has long been held by many educators and accepted by many employers that the technical skills can be quickly learned by intelligent men well-grounded in these basic sciences. Some of this country's greatest industrial firms are today selecting science-trained graduates of liberal arts colleges and quickly preparing them for highly technical jobs through "in-service" training.

Another important part of this foundation is found in liberal arts. Even those who demand a high degree of technical training recognize the importance of the liberal arts, and insist upon a certain ability in both written and spoken expression and a knowledge of life and living that cannot be gained from scientific or technical study alone. Therefore, courses in composition, speech, literature, history, and economics are required in general forestry school curricula to satisfy these needs. Some schools may require even more in the liberal arts field.

Employers also desire some knowledge of business methods regardless of the type of employment concerned. This field is covered, at least in part, in most forestry schools by various courses in which the fundamentals of administrative management, accounting, and statistics are offered. These

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may be given as applied courses, but although related to forest management as taught, have application in other fields. In addition to these required courses, opportunity exists for additional study in this field, as most universities offer a number of business subjects which may be elected.

In the engineering field the general forestry curriculum usually offers only surveying and mechanical drawing. Perhaps something may be offered in regard to communication equipment, and a little in design of roadways and simple structures. It is probably in this general field of engineering that the forestry curriculum is weakest as far as the manufacturing phase of forest products industry is concerned. Notably lacking are courses in electrical and mechanical engineering though mechanics is touched upon in wood technology courses.

Utilization Covered Adequately

The forestry school graduate is fairly well versed in the field of wood itself and in its utilization. With the idea in mind that the producer of a raw material must know that material well and must understand the needs and problems of its user, this field is well covered. Courses are required in wood identification, wood structure, and wood properties. The utilization of wood is represented by courses in logging, lumber manufacture, and usually a course covering in at least a general way the production of the many other products made from trees or wood. Also available are courses in the preservation of wood and in its proper seasoning. Special work in any of these subjects is available to certain students especially qualified for advanced work as undergraduates.

The question may well be raised at this point as to the value of that part of the forestry school curriculum devoted to forest management, tree growing, and protection. It may be of considerable value as supply problems force manufacturers to take an ever greater interest in producing raw material. At least, it can do no harm for the manufacturer to appreciate the problems of the producer of wood.

Forestry school faculties are never sorry when men trained in good forestry practices are infiltrated into the manufacturing phase of industry where appreciation of the importance of good forestry may at times be lacking. The powerful influence of organized forest industry has done much to forward good forest conservation practices in recent years and must do still more as an expanding population demands more wood products. All phases of forest industry are needed in support of this program.

It would not be fair for the forestry school to claim all the credit for the success of those among its graduates who have entered industry. In recent years particularly, these men are availing themselves of advanced study at graduate schools where specialization in products work is available or are taking special training in short courses offered by industry itself, as well as by certain universities and other agencies.

It is not claimed that any forestry school graduate could fit well into the manufacturing or other non-forestry phase of industry. It is, however, pointed out that a fair percentage of them especially fitted by inclination, experience, or special training have successfully entered forest products industry in the past, are doing so now, and probably will continue to do so in the future. Also, it may be that in those industrial organizations that grow their own wood supply the forestry school graduate may well be better fitted for high executive position than one less broadly educated.

Gluing and Fabricating Flush Doors[1]

JOSEPH W. COUFAL[2]

Discusses factors influencing growth of hollow-core flush door industry. Changes in the industry in recent years and their effect on door production and the type of product are described. These include core materials, door faces, glues, and gluing processes. Several opportunities for future developments are pointed out.

DURING THE PAST five years the flush door industry has grown to such size that it now produces in excess of 13 million doors per year. Since we may safely assume that there are about seven doors to a living unit, it follows that six out of seven flush doors produced are of a hollow-core type since they are used for interior purposes.

The tremendous demand for this kind of door has not slackened and apparently will not as long as the building boom continues. It has gained preference due to its light weight, modern styling, variety of surfaces, low cost, and ready ability to be easily produced locally. In fact, the relatively simple production of hollow-core flush doors coupled with a low financial investment for equipment and plant has resulted in an extremely competitive industry.

A few years ago, most of the hollow-core doors were produced by a few manufacturers in several areas who were able to sell these doors within a radius of 1500 miles. Some of these plants each produced as many as 5,000 and 6,000 doors per day, giving such a manufacturer the advantage of large purchasing power for materials delivered to one plant.

Today, there have sprung up within a few miles of every major expanding city smaller local hollow-core door manufacturers. These plants generally are set up to assemble and trim doors rather than build them from scratch. They use pre-cut, pre-surfaced stiles and rails, ready-for-use core materials, veneer skins or hardboard cut to size and ready for assembly, low-cost trim operations, and space-saving, fast, simple gluing techniques. The larger manufacturers have been forced to decentralize and to locate smaller assembly plants more locally throughout the country to compete with the smaller manufacturers. Being a local producer of hollow-core flush doors is advantageous because of: (1) savings on freight, (2) ability to deliver quickly plus pick-up facilities, (3) local direct sales representation, and (4) benefits derived from being a part of the community.

Everyone is sufficiently familiar with the make-up of flush doors and the manner in which they have been pro-

[1] Presented at meeting of FPRS Northeast Section, April 19–20, 1956, in Springfield, Mass.
[2] Mr. Coufal was Sales Supervisor of National Adhesives Woodworking Dept. when this paper was presented.

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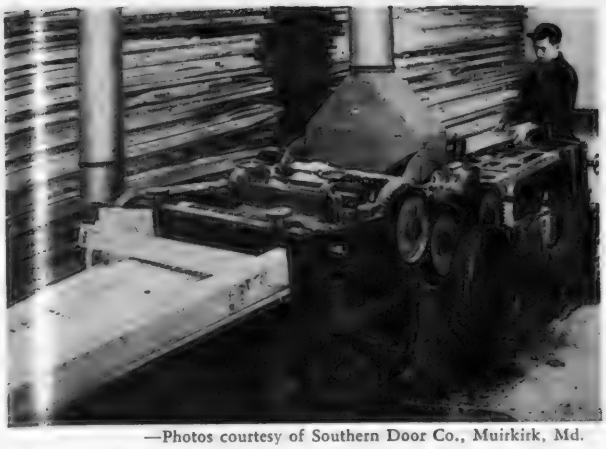

—Photos courtesy of Southern Door Co., Muirkirk, Md.

Fig. 1.—Gang ripping and planing of door stiles by single machine.

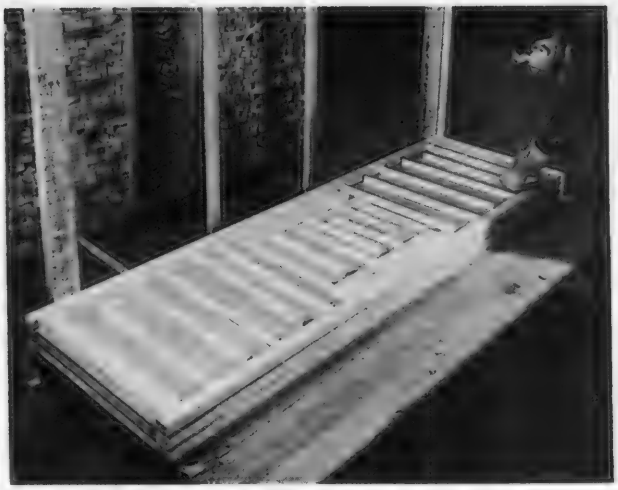

Fig. 2.—Door lay-up showing frame and wood core.

duced in the past so that this may be touched on briefly. Prior to 1951 they generally consisted of white pine or fir stiles and rails with a similar wood ladder or mesh core. They were usually bonded with urea resin and casein adhesives. There was some soya protein, a little vinyl resin, but no contact cements used. The skins were mostly fir, maple, birch, and gum, with a fair portion of imported mahoganies.

What is the status today then? What have been the changes during the last five years and how have these affected the production of doors and the finished product?

While the stiles and rails have remained essentially the same woods and the same sizes, the core materials have changed. It is true that wood is still predominantly the core used today, but it is holding its position mainly because of low cost and not because of structural superiority. The mesh wooden core is definitely now in the minority with the wood ladder construction remaining.

Insulation board has made some real strides during the past few years and now is generally accepted as equal to a wooden core door. Advantages of insulation board are as follows: uniformity of thickness, easy gluability, ability to resist warpage but not to cause it, eliminate "ridging or telegraphing," ease of handling in lay-up, lighter door, and produces a sound strong door.

To the door manufacturer who does not have a ready, low-cost wood core supply at hand, insulation board provides one suitable answer. There is a larger future for this type of core material, especially due to the "assembly" nature of the door industry today. However, one of the major reasons for this core not being more widespread today is the lack of promotion by the insulation board manufacturers. There has been little direct effort or concern pointed towards the door industry's needs. Consequently, insulation board sales as a hollow door core material have suffered.

Those distributors who have previously insisted on a wood core door have also been forced to recognize paper honeycomb in addition to insulation board core. Today, many thousands of hollow-core flush doors are being manufactured from paper honeycomb. Honeycomb produces one of the most stable, warp-resistant, durable doors. It is light in weight yet exhibits high shock and crush resistance. The real beauty of the honeycomb core is in its insertion into the frame prior to gluing. The core comes in a folded, space-saving condition and is then glued to the top and bottom rails. When the frame is assembled, the honeycomb is expanded and thus automatically becomes part of the frame. The entire frame and core assembly then passes on a moving belt through a pinch roller device to properly size the honeycomb to the exact thickness of the core and then on another belt through the glue spreader to the lay-up crew. The time saving advantages in the lay-up are obvious.

Still another core used today is that of regular double-faced corrugated kraft board. This board is sliced into thicknesses equal to that of the frame. It is passed through the glue spreader on edge and placed on edge into the door as a core. These strips are usually about 5 inches apart. The door is given increased strength by the addition of 2 center wood strips about 1½ inches in width. These corrugated strips provide a suitable core together with great speed of lay-up assembly, savings in adhesive, and a low cost core material factor.

Due to its low cost, decorative appearance, and the public's general swing to darker woods, the imported mahoganies are in the majority in re-

Fig. 3.—Air presses clamping doors without use of I-beams and retaining clamps.

Fig. 4.—Storage area for finished doors before shipment.

gard to interior hollow-core doors. Hardboards have made nice gains in the paint-grade door market and also in the closet sliding door field. It must be pointed out that while the mahoganies and the hardboard doors have their certain advantages, the low cost factor of these skins has been the major cause for their popularity. Birch and maple-faced doors still predominate in the better quality homes. Another import which is gaining favor is German beech.

The door industry has settled on no single adhesive as the best with which to glue hollow-core flush doors. Rather, it has selected on an individual basis depending upon the production needs of the plant, gluing facilities, storage space, initial investment for a new plant or an addition to the plant, and other such factors. Let us by no means exclude the fact that many, if not most, firms buy first the technical knowledge of their glue salesman and the quality of the firm which he represents. Second comes the type of glue. The easiest thing in the world is to produce something cheaper. The door industry has learned what other woodworkers have known for years, "Keep as a supplier a glue salesman who knows and earns his living from the wood industry and his glue will usually work."

The years 1951 to 1956 have seen the emergence of vinyl resin and soya-protein as major factors in hollow-core flush door adhesives. The West Coast uses a great deal of soya. The Wisconsin area uses much casein, but throughout the remainder of the country vinyl resin and urea resin predominate.

During the past 2 years in the East, Mid-West, and far South, the large manufacturer who is decentralizing and the smaller local producer just opening up have been helped by the Kwik-Klamp process. This involves the utilization of low-cost fire hose presses using air or water pressure plus a fast-setting vinyl resin. Clamp time usually runs 20–30 minutes and then the doors are removed from the press onto a storage conveyor leading to the trim saw. There is no need for I-beams, retaining clamps, or heated curing rooms. This process will operate in temperatures as low as 50° F. The adhesive requires no mixing, has a permanent pot life, is non-toxic, and practically non-abrasive to the trim saws. The glue spread is low, usually about 7/10 of a pound per door, and the doors may be trimmed 2 to 3 hours after release from pressure. Purchasing of vinyl resin in truckload or tank truck lots lowers the cost of the adhesive to a level competitive with the other types of adhesives.

Soya-protein utilizes a similar process on the West Coast with the following differences. The glue is mixed by the door manufacturer together with blood albumen, caustic soda, water, and several other ingredients. The curing time before trimming is usually a minimum of 6 hours—mostly longer depending on the humidity conditions. The glue spreads employed are over a pound per door.

Urea and casein adhesives are still utilized as they have been for years. Casein comes in powder form. It is mixed with water and enjoys usually about a 6-hour pot life. It requires high glue spreads and overnight clamping with I-beams and retaining clamps. Urea resin comes in liquid form. It is mixed with a powdered catalyst and has pot life from 2–6 hours depending on the catalyst and the temperature conditions. It requires a clamp period of 5 hours to overnight without heat to cure. Heated curing ovens lower that time to 3 hours. This adhesive causes irritation when it comes into continual contact with bare skin and therefore requires protective clothing. It is extremely abrasive to trim saws. Its mileage is the same as that of vinyl resin.

Also in use today are vinyl resin combinations. Urea is mixed in its regular manner and then when ready it is added to a vinyl resin. The amount of urea added depends on the properties of the final bond desired and the manner in which the doors are glued and pressed. The urea lowers the cost and improves the water resistance of the vinyl. The vinyl helps the urea by extending the pot life, giving a much greater speed of set, and providing a less abrasive glue line.

Before leaving the glues of today, I must regrettably inform you that as yet no adhesive manufacturer has developed a "non-warp" glue, nor is such a product in sight. From coast to coast you hear attacks on each of the above mentioned glues and similarly stout claims in defense of them in regard to warpage. The truth is that none of these glues causes nor prevents warpage. This condition has in the past and will in the future depend on the moisture content of the door's component parts and the relative humidity control of the manufacturer's plant.

Because of the simple construction of a hollow-core door and its ability to be easily produced, the field has become highly competitive as previously stated. Now, many manufacturers complain that there is no money left in the door industry. Some of these talk of leaving the field completely. This is a mistake, for close at hand are the "door-like" constructions of the future.

What about movable wall partitions? How many door manufacturers know that 8 miles of these partitions made of mahogany skins laminated to a fireproof composition core went into the Ford Motor Company's new Administration Building? We have not yet talked of contact cements. Spray onto both surfaces, dry under infrared lights for one minute, combine with a pinch roller, and it's done. Overhead garage doors fabricated of hardboard with a honeycomb core are being produced today in this fashion. Contact cements also make metal-faced doors a simple production item insofar as gluing is concerned. Kaiser is now

producing a gold aluminum. Is there a future with such a medium?

Foam glass, fibre glass, and polystyrene all make excellent fire resistant, insulating, sound-proofing core materials. Yes, they are expensive simply as a core material in a regular hollow-core door. But they hold great promise in doors or partitions requiring these other properties. And what of polyurethane foams—the liquid which may be spread into either end of the door and which will foam in place to produce a core?

It is not inconceivable that doors may one day be fabricated on impregnated tiny celled paper honeycomb core material faced with a single thin (1/64-inch) veneer backed up with kraft. The exterior of the veneer might then be protected by a transparent polyester sheeting such as Mylar. Mylar has tremendous scuff, impact, and tensile properties and can be readily washed. It may currently be found on the bottom kick plate in the doors of some of the newer automobiles.

The present day hollow-core flush doors have become a common commodity. Anyone can produce them competitively. It remains for the forward looking door manufacturer to investigate other similar fields for further expansion plus a program of experimentation with new mediums. The opportunities exist now.

Many other significant advances are being made through modern chemical research as applied to core materials. It is up to the door manufacturer who has a history in this type of fabrication to develop them.

How to Prevent Insect Damage to Wood Structures[1]

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Insect damage to wood materials in storage and in structures amounts to millions of dollars annually. Most of it is preventable. This paper discusses the various types of insect problems and the situations under which they develop, describes the insects' activities and the damage they cause, and suggests methods of preventing insect attack.

GENERALLY SPEAKING, the most effective and simplest method of insect control is the preventive one. This is true in all biological relationships in which insects play a part—whether they involve the health of man, the food he eats, the clothing he wears, or the wood products he uses. Unfortunately, the value of preventive measures of control is rarely recognized until substantial injury has been done.

When wood structures are involved, the cost of the damage is usually very substantial, for it involves replacement of damaged units as well as application of control measures. Estimates of losses by the lumber, furniture, and building industries are extremely difficult to obtain. We know that damage to innumerable wood products such as stored lumber, furniture, dunnage, tool handle stock, and to homes and other wood structures runs to scores of millions of dollars per year in the U. S.

Most of this damage and loss is caused by two general groups of insects: termites and powder-post beetles. The number of economically important individual species of termites and beetles, plus a few miscellaneous wood products insects, approaches 100. Most of these differ from one another to a greater or lesser degree in appearance, habit, food requirements, and life history. Thus, the task of identifying the insect and its damage and properly applying preventive or remedial methods of control may be a complex one. This paper describes the more important insect groups and discusses their habits and damage in relation to control.

[1] Presented at Session III, Wood Preservation, FPRS Tenth National Meeting, June 4–7, 1956, in Asheville, N. C.

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Termites

The average individual thinks of termites simply as winged pests or flying ants. What he sees is the colonizing winged form of one species of termites. In reality there are 55 species of termites in the United States, and technically they fall into three habit classifications: subterranean termites, drywood termites, and dampwood termites. The drywood and dampwood termites are economically important only in southern Florida and the extreme southwestern United States. Subterranean termites are found in most states except parts of New England, New York, Minnesota, North Dakota, South Dakota, Montana, Wyoming, Utah, and Colorado. They comprise by far the most important group of wood products insects and are most destructive in the South.

Subterranean Termites

Characteristics: Subterranean termites derive their name from the fact that they live in the soil and must maintain contact with it. They are generally distributed throughout it, so that no building is free of the danger of attack. There are several termite forms within a termite colony, the destructive one being referred to as the "worker" which feeds on any cellulose product and is capable of performing seemingly impossible feats in order to reach it.

Normally workers feed on wood in or on the ground. When this is exhausted, they will construct earthen tubes over almost any obstacle or will chew their way through noncellulose materials to reach it. Once established, they can carry their moisture to drywood and maintain a satisfactory atmosphere. They will chew through soft metals, rubber, leather, soft mortar, etc., to reach food.

Preventive Measures: Structural Practices—The key to keeping subterranean termites out of buildings lies in construction practices. This is more easily said than done. The author has just completed an assignment on an advisory committee to the National Research Council studying termite and decay prevention in new construction. It was amazing to note the complexities which developed in efforts to assemble known facts which could be applied reasonably and practically by architect and builder and be accept-

able to homeowners and all other parties concerned.

Termite activity can be discouraged by grading the building site to keep moisture away from the buildings and by eliminating stumps, wood scraps, and other cellulose materials from the site. Buildings with a crawl space should be well ventilated below to decrease air moisture as much as possible. Wood should never be in contact with soil; in crawl spaces it should be at least 18 inches above the soil. Exterior wood should be 6 inches from soil. Foundations should be impervious to hidden access by termites. Solid concrete is preferable; hollow block or tile should be capped with a 4-inch-thick poured reinforced cap which will bring termite activity into the open. Vertical cracks 1/64 inch or larger in these units will permit hidden termite penetration.

Metal termite shields can be an effective construction barrier to termites, but they must be properly constructed and installed. Perhaps 95 per cent of all shields installed to date have been ineffective and the money expended completely wasted. To be effective, shields must have double locked joints or joints must be riveted and sweated. Only the following metals should be used: galvanized iron, corrosion resistant, 26 gauge; zinc, .024 inch thick; 16 oz. cornice-tempered copper; Terneplate 1C or 1X 40 lb. coating painted on both sides. Termites can chew through tarred felts, roofing papers, metal coated papers, and similar materials sometimes used as shields.

Bolt holes in shields must be sealed with a nonasphaltic compound such as roofer grade coal-tar pitch or rubber base compound. Shields must be maintained to see that the horizontal and angular projections, upon which their effectiveness against termites depends, are retained (Fig. 1).

Use of treated wood—There are numerous instances when despite all precautions buildings may become susceptible to termite damage; there is no such thing as "termite-proof construction." This being the case, the use of wood treated with preservatives is desirable. Wood which is in, on, or near soil should be treated. Load-bearing timbers susceptible to decay and termites, particularly sills, plates, and headers, should preferably be pressure treated. Door frames, window frames, and similar units near soil should be pressure treated or at least have a surface application of preservatives.

It must be emphasized that while termites will not bore into properly treated wood, they can build earthen tubes over it to attack untreated wood. Therefore, preservative treatments as suggested here only serve to protect critical timbers and bring termites out into the open. Ideally, of course, it would be desirable to treat all the wood in the subfloor space as extra insurance against both termites and decay.

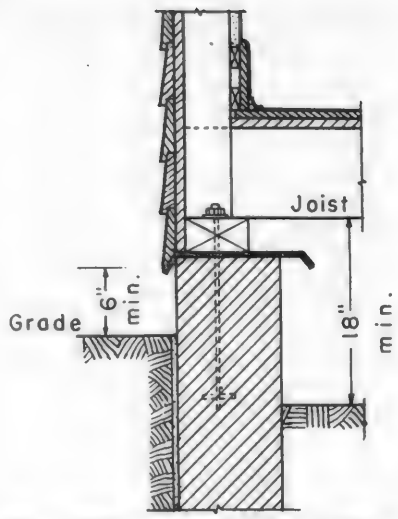

Fig. 1.—Diagram showing required clearance between wood, soil, and termites.

At this point it might be well to mention that many of the surface treatments currently used during construction give only superficial penetration and very little protection to wood. Wood should be dipped or soaked in the preservative solution—at least three minutes and overnight would be better. If dipping and soaking are impractical, then the wood should be given several liberal brush coats of preservative liquid after the piece is cut to form and before it is nailed into place. Spraying is not advisable but may be used in lieu of brushing when access is a problem. The treatment of wood in place by drilling, as sometimes practiced in termite control, is not an adequate preservative treatment. It has limited value in special situations in control of infestations.

Chemical Treatment of Soil—One of the most effective means of preventing subterranean termite attack is by chemical treatment of soil adjacent to the foundations of buildings. While the treatment is a supplement to good construction, there are situations in which it is the only means of preventing termite attack.

Statements made thus far on termite prevention have been general, with occasional references to conventional construction. However, we must consider the slab-on-ground construction, which has become increasingly popular. Often considered termite-proof, it is probably one of the most susceptible to termite attack and one of the most difficult to treat. Termites may enter through cracks in the slab, through expansion joints, and at points where plumbing enters the building. In this type of building, chemical treatment of the soil before construction is particularly valuable.

The following recommendations are made for pre-treatment of building sites.

Crawl Space and Basement Buildings—Apply chemicals in trench along sides of foundation walls, posts, or piers at rate of 4 gallons per 10 linear feet. For basement construction, this dosage should be doubled. As the trench is backfilled, the soil should be thoroughly mixed with chemical so that all of it, from footing up to grade level, is treated. Soil under attached porches, entrance platforms, etc., should receive an overall soil surface treatment of 1 gallon per 10 square feet. Unit masonry foundations should receive a void treatment of 1 gallon per 5 linear feet.

Slab-on-ground Construction—When the foundation is laid and the fill is complete, the fill should be treated with 1 gallon of chemical per 10 square feet. The dosage should be increased by at least ½ for coarse fill such as washed gravel or cinders. Critical areas, such as along foundation walls, interior walls, or utility entrances, should be treated at rate of 4 gallons per 10 linear feet.

Soil Chemicals—Study has revealed that a number of recently developed insecticides have proven effective and long-lasting in termite control. These are now being used rather generally in the termite control industry: benzene hexachloride, 0.8 per cent gamma isomer; lindane, 0.8 per cent, chlordane, 1.0 per cent; dieldrin, 0.5 per cent. These may be used in water emulsion or in oil. DDT, 8.0 per cent in oil, and sodium arsenite, 10 per cent in water are also good, although the latter is highly toxic to animal and plant life. Chemicals such as pentachlorophenol, orthodichlorobenzene, trichlorobenzene, and others, though limited in various ways, are still rather widely used in termite control.

Drywood and Dampwood Termites

Characteristics: These termites, common to the tropics and subtropics, generally concern few of us. However, in their native habitat they can cause serious damage and it is not unusual to find them in furniture and other wood products moved from tropical to temperate climates.

In general form and habit they resemble subterranean termites with this big difference: they attack wood directly and spend most of their lives in it. For this reason they are considerably more difficult to contend with than subterranean termites. General infestations throughout a building often can be controlled only by fumigation of an entire structure; and unless preventive measures are taken infestation may re-occur.

Perhaps the best evidence of drywood termite activity, in addition to the swarming flight of the winged adults, is the presence of what are referred to as "pellets". These are symmetrical bits of woody refuse, the size of a head of a pin, which are pushed out of cavities which termites are excavating. This evidence usually permits the location of an infestation and an observant individual can frequently pinpoint the attack before it becomes serious.

Preventive Measures: Use of Treated Wood—In areas where incidence of termites is high, the treatment of all wood in a structure seems highly desirable. Critical timbers, which may be exposed to other forms of deterioration, should be pressure-treated with an approved preservative. Other timbers should receive at least a surface-treatment with approved materials by suitable processes.

Other Preventive Measures—In areas of lower hazard, other forms of control may be satisfactory. Exterior woodwork should always be well painted to minimize the points of termite access. Windows, doors, and other points of entry should always be fully screened. Timber which cannot be protected by these means should be treated with preservatives.

As soon as termite damage is observed, the infested unit should be surface treated by brushing or spraying with insecticides; if badly infested, it should be replaced with treated wood. Deep infestations sometimes require injection of insecticides by drilling.

Insecticides—Recent results of studies conducted by H. R. Johnston in the Canal Zone reveal interesting data on insecticides in preventing drywood termite attack. In general, dip or soaking treatments gave far better protection over a 4-year period than did brush treatments. Only 5 per cent pentachlorophenol in trichlorobenzene and 5 per cent DDT plus 2 per cent chlordane in petroleum oil gave complete protection applied as brush coats. Surface treatments applied as 5-minute to 4-hour soaks gave complete protection when the following insecticides were used: straight trichlorobenzene; chlordane 2 per cent plus DDT 5 per cent in trichlorobenzene-kerosene; pentachlorophenol 5 per cent in mineral spirits; copper naphthenate, 4 per cent metallic copper.

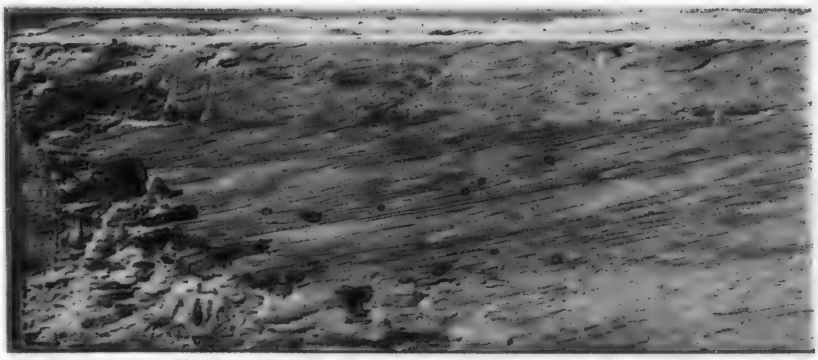

Fig. 2.—Flooring damaged by Lyctus powder post beetles.

Powder-Post Beetles

The group of insects known as powder-post beetles, while somewhat less destructive than termites, are more complex and therefore more difficult to control. In the pest control industry the operator is usually reluctant to accept a control job, and if he does so a guarantee is seldom provided. There is so little known about these insects that damage is usually rather well advanced before it is observed.

As the name indicates, powder-post beetle damage is characterized by the presence of fine powdery wood dust caused by the feeding activity of the immature insect or larvae. The general life cycle of powder-post beetles is as follows: The adult beetle lays its eggs in pores, crevices of wood, or under bark strips. The wood may be moist or dry. The eggs hatch into larvae which proceed to mine out the wood. The success of their efforts depends on many factors: the moisture content of wood, its structure, but most of all its starch content, for it is the starch which provides food for the species. The same species of powder-post beetle may spend from one to many years as a larva, depending upon the food available.

There is a general belief that moisture is a critical factor in the success of beetle attack, though the limits have never been defined for the various species. When the larval period is complete, the insect goes into a resting stage, changes into an adult beetle, and emerges from the wood. It may or may not reinfest the wood, depending upon the species and the condition of the wood.

Lyctus Powder-Post Beetles

Lyctus beetles, which are worldwide in distribution, are probably the best known of the powder-post beetles. They may attack green lumber in the yard, air-dried, or kiln-dried lumber. In this country only hardwood species are attacked, and the large-pored species most frequently. Flooring, furniture, tool handles, sporting goods, and many similar items are damaged (Fig. 2). This point should be emphasized—infestation almost always begins during storage of the product, as in warehouses where the food supply and breeding environment is at an optimum.

The adult beetles, which are seldom observed by the layman, are small blackish beetles, which on emerging make a hole about 1/16 inch in diameter.

Anobiid Beetles

The anobiid beetles are probably the next most common of the powder-post beetles. It is rare to find a building in the South, particularly the crawl space type, that does not have some infestation in the pine subfloor timbers. While the various species may be found in hardwoods or softwoods, in sapwood or heartwood, damage to pine is most common. The well-known death-watch beetles and furniture beetles are members of this group.

Adults of the most common species of anobiid are brownish in color, are about 3/16 inch long, and on emergence from wood make holes about 1/8 inch in diameter.

Longhorn Beetles

To the longhorn beetle group belongs one of the most destructive of the powder-post beetles known as the old house borer, *Hylotrupes bajalus*. Damage by this large insect is becoming increasingly common throughout the world and its common name appears to be a misnomer because it is found in relatively new construction. In some parts of Europe and Africa this is the No. 1 enemy of wood products.

The adult beetle is blackish, clothed with long gray hairs; it is thick-bodied, up to 3/16 inch wide and 7/8 inch long. It lays its eggs in green or seasoned softwood in cracks or under bark edgings. Eggs soon hatch into

larvae which feed in the sapwood. They may feed from one to several years and at maturity are over an inch long. The larval channels in the wood and the emergence holes of the new adult may be up to ¼ inch in diameter.

There are a rather large number of other species of longhorns which may constitute a problem in construction. Some, such as the red-headed ash borer, may attack green logs, and continue to damage and reinfest the timber year after year. Others attack green logs or lumber, complete their life cycle in the wood wherever it may be used, and emerge without reinfesting the wood in construction.

During World War II a great deal of "green" lumber went into construction, and soon thereafter longhorn beetles emerged within dwellings through wallpaper, wallboard, and even plaster. Currently, a considerable amount of Douglas-fir timber is on the market from which beetles are emerging in construction; much of this timber was salvaged from fire- or insect-killed areas. Some of the borers in the timber may require from one to several years to emerge from the wood.

Other Powder-Post Beetles

There are a rather large number of other powder-post beetles which occasionally create problems more or less severe. In the family *Bostrichidae, Curculionidae,* and *Ptinidae* are a number of such species. Space does not permit detailed discussion of these various groups.

Preventive Measures

Lyctus Powder-Post Beetles: Green lumber—Recent studies have shown that a 10-second dip in 5 per cent DDT or 0.5 per cent gamma BHC cold water emulsion will prevent attack during normal storage periods. Results were considerably better than with microfine sulfur or borax used in the past.

Seasoned lumber—Generally a good program of sanitation in warehouses will prevent attack of lumber and similar items to be used in wood structures. Periodic examination of stored stock and destruction of badly infested material are sufficient.

Wood preservatives—Though use of preservatives is not generally considered necessary for Lyctus control, on occasions it may be desirable. Such insecticides as 5 per cent DDT, 5 per cent toxaphene, 2 per cent chlordane, and 0.5 per cent lindane, applied as 3-minute dips, have given excellent protection under severe exposure to Lyctus for more than 5 years. Approved pressure or dip treatments in approved preservatives give long-time protection.

Other—It might be of interest to note here that in Australia where the Lyctus problem is a severe one, investigations into plywood protection and the use of preservatives in glue joints have been made. A large series of insecticides were added to cold-setting glues, the plywood assembled and exposed to attack. After 3 years of exposure, only DDT and BHC had given complete protection in all concentrations used.

Other Powder-Post Beetles: Generally, there has been little research into the fundamental habits and biology of most powder-post beetles. Necessary knowledge is particularly lacking for the furniture beetles, the old house borer, the bostrichids, and others which rather frequently attack timber after installation in the home.

Preservative treatments, particularly pressure and possibly soaking in approved preservatives, will probably prevent attack indefinitely. Short dip treatments, brushing or spraying with preservatives or such insecticides as 5 per cent DDT, 5 per cent toxaphene, 2 per cent chlordane, or 0.5 per cent lindane are apparently very effective, but the period of protection is still indefinite.

Proper treatment of green logs and lumber can prevent initial attack by wood-boring insects. Winter cutting and storage reduces attack. Spraying of stored logs with BHC, 0.5 per cent gamma in oil, and dipping of stored lumber in BHC, 0.1 per cent gamma in water emulsion, give a high degree of protection not only against borers but also against the defect causing ambrosia beetles. Removal of bark edgings will also prevent attack.

Dry-kiln treatment of wood is often considered a good insect control measure. It is effective in killing eggs and larvae within the wood if properly applied, and it will prevent attack by insects requiring green wood. However, it will not prevent re-attack by those insects which can infest seasoned wood.

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Discussion

John Reno (Pacific Lumber Co.): If the woodwork in a house is treated with a 5 per cent brush treatment, how long will the protection last?

Mr. Kowal: I do not know exactly how long the protection would last. Some results indicate protection is good up to four years. Tests now in progress at our Gulfport, Miss. laboratory will yield data on the life of various chemicals.

Mr. Reno: Are some woods such as walnut, mahogany, or African mahogany resistant to dry wood termites?

Mr. Kowal: No commercial wood is known to be resistant.

W. W. King (Tennessee Valley Authority): Would this treatment work well with a proprietary preservative?

Mr. Kowal: It depends upon the active ingredient used. Most proprietary preservatives are satisfactory. Good or bad results usually depend upon the thoroughness of application. At least three coats are required; each must be absorbed before the next is applied.

Mr. King: Would this apply also to spray?

Mr. Kowal: Spray is inferior to brush treatment. It may be used, however, particularly in locations inaccessible to brush treatment.

Around the World in Forest Products Research and Development

Wood Industry Advances in New Zealand

Wood products now rank as New Zealand's fourth largest industry, with a value rapidly approaching that of wool, meat, and dairy products, the country's chief exports. One of the principal means for wood's recent rapid growth is the maturing of the 350,000-acre Kaingaroa Forest.

To handle the harvest from Kaingaroa, the timber industry has become highly mechanized. Being utilized are power saws, cranes equipped with air tongs to lift the logs onto trailers, and conveyor systems to feed in endless flow the saws, planers, digesters, and other machinery used in manufacture of wood products.

Three companies have achieved major importance in New Zealand's timber industry. Whakatane Board Mills Ltd. draws on some 60,000 acres of trees to supply raw material for its production of packaging board. New Zealand Forest Products Ltd., possessing 176,000 acres of timberland, produces 65,000 tons of chemical pulp annually. The first chemical pulp made from locally grown pine was produced in 1953 by this company. The New Zealand government holds major interest in Tasman Pulp and Paper Co., Ltd., an $80 million organization which operates an integrated sawmill, pulp and paper mill operation at Kawerau. The mill is now one of the world's four largest and will soon be doubled in size. A geothermal power station is being constructed in an effort to tap the region's natural steam as a power source.

The largest forest ever planted by man, the Kaingoroa area was a sterile wasteland 50 years ago. Interest in conservation led to plantings of trees from other parts of the world, including Douglas-fir, Corsican pine, ponderosa pine, larch, and Monterey pine. It was found that Monterey pine grew larger and faster in New Zealand than in its native California, and huge acres of it were planted by the government, private individuals, and companies.

—Oil, Lifestream of Progress, January, 1957.

Other Developments Around the World

Yugoslavia

• Scientific research in forestry and forest products before the war was fostered exclusively by Beograd and Zagreb Universities. Since the war five forestry institutes have been founded (at Beograd, Zagreb, Ljubljana, Sarajevo, and Skoplje) and one Wood Research Institute (Zagreb.) In addition, the Yugoslav Academy for Science and Art founded an Institute for Experimental Forestry. These seven institutes have a yearly budget of about 130 million dinars, equal to about 0.08 per cent of the gross earnings of this branch of the economy.

With the exception of the Institute for Experimental Forestry of the Yugoslav Academy, all the remaining institutes have autonomous financial self-administration and are thus forced to deal primarily with operative problems, particularly those of service.

Scientific research in connection with the industrial transformation of wood is mainly concentrated in the Zagreb Institute for Wood Research but the Forestry Institute of Beograd, Ljubljana, and Sarajevo also have Departments for Wood Industry. The work is developing in five directions: forest harvesting, mechanical transformation, chemical utilization, engineering, and documentation.

—Yugoslav Timber Industry, 1945–1955.

England

• The tenth anniversary of the Wood Forum was held recently in London, England. Founded on August 30, 1946, by Dr. S. E. Wilson, the group's purpose is: "to provide opportunities for wood specialists and people directly concerned with the commercial and industrial aspects of timber to meet primarily to discuss wood in its technological, rather than its strictly commercial relationships." The first formal meeting was held on October 2, 1946.

In addition to formal discussions on topics selected in advance of meetings, the Forum holds informal meetings, where members exhibit specimens associated with wood and comment on them.

Scanning World-Wide Forest Products Publications

Australia

A Precision Frame Gang Saw Built in a Sawmill, Part I. D. S. Jones, C.S.I.R.O. Forest Products Newsletter. No. 219.

The frame gang machine is fabricated of welded steel plate and has a sash width of 4 feet. The usual operating speed is 160 strokes per minute and feed speed is generally about three feet per minte but can be increased up to 14.

The reciprocating sash is supported on four rollers mounted on ball bearings and running in vertical channels. Each roller is automatically lubricated. Two connecting rods, one on either side, drive the sash in an oscillating motion, i.e., forward into the cut on the down-stroke and away from the cut on the up-stroke.

The saw blades are mounted between top and bottom cross beams of the sash by using hangers riveted to the blades. The blades are tensioned by driving wedges between the top hanger and a specially designed spring-loaded support. When inserted the blades are virtually spring-loaded and therefore do not loosen during service.

The blades used in this machine are seven feet long by six inches wide by 13 gauge, and the teeth are swage set to approximately 8 gauge (0.035 inches on either side of tooth). Experience has shown that the best hook angle is 17°. For good swaging the sharpness angle must be as near as possible to 44°, so the clearance angle becomes about 29°. Blades are rolled similarly to bandsaw blades to eliminate snaking in the cut, and new blades are inserted every four hours.

The feed mechanism of the frame saw consists of two pairs of fluted feed rollers, an infeed pair and an outfeed pair. The top roller of each pair can be pneumatically raised or lowered, and is used to apply downward pressure on the log during cutting. All four feed rollers are powered and the feed is continuous. In front of the bottom infeed roller is a 10-inch diameter two-knife planing head, to cut a narrow flat surface on the bottom of each log before it enters the saw. The cutter knives are changed each day.

Abstracts From Current World Literature

Hardboard

Ernest Joyce. The possibilities of hardboard in furniture manufacture: part 2. *Furnishing*, Vol. 72, No. 2, February 1956, pp. 113–4.

Of the three grades of hardboard now being manufactured, the standard grade has most application in the furniture industry although the super grade is more suitable for humid atmospheres.

Great ingenuity is being shown in developing textured surfaces, the most popular being perforated or peg board which was originally produced as an acoustic material but is now used where adjustable hooks are an advantage. Board embossed with grain or figure effects and colored boards are also made.

Contrary to expectations, because they are heavy, do not take screws readily and are difficult to join, hardboards are unsuitable as structural members for furniture. [F. D. C. Tech. Bul. V. 6, No. 32]

Seasoning

O. Krischer. Die wissenschaftlichen Grundlagen der Trocknungstechnik (The scientific basis of drying techniques). Lange and Springer, Germany.

This book, published in June 1955, is a treatise on the technical and scientific principles involved in the various industrial drying processes.

It deals with material and energy conversion during drying; the basis of heat transmission; movement of materials by flow and diffusion; heat conductivity of material in the moist state; the influence of external conditions on drying time; the influence of shape on drying progress and an example of the analytical treatment of drying processes.

A separate section outlines the mathematical treatment of heat exchange when drying hygroscopic materials such as spun fibers and timber by high-frequency processes. The final section deals with the determination of moisture content. [F. D. C. Tech. Bul. V. 6, No. 32]

Machining

H. J. Endorsby. The blunting of wood-cutting edges. *Forest Products Research Special Report* No. 11, 1956.

The performance of a cutter depends largely upon the forces which the cutting edge is able to withstand. If parts of the edge break away in use, blunting is accelerated, but careful sharpening helps to avoid this.

The sharpness angle of the cutter does not so much affect the ease and cleanness of cutting as reduce the rate of blunting.

An angle of 40° should provide good wearing qualities, but when this is reduced to 35° or less the cutting edge tends to break away rapidly. With blocks machined to give a cutting angle which is smaller than normal, the width of the back bevel can be made fairly large to resist the additional load.

Edges formed in tungsten carbide compare very favorably with those made of high-speed steel, while cobalt-chrome-tungsten alloy has proved to be very brittle. [F. D. C. Tech. Bul. V. 6, No. 32]

Waste Utilization

Millikin, D. E., Determination of bark volumes and fuel properties. *Pulp Paper Mag. Can.* 56, no. 13: 106–8 (Dec., 1955).

A systematic summary of the fuel properties of the bark of various species of wood generally used for producing steam power is presented, with information on the heating value, chemical analysis, ash analysis, bark weight and density, and fusion temperatures for balsam, jack pine, poplar, white and yellow birch, hard and soft maple, soft elm, beech, tamarack, eastern hemlock, and black, white, and red spruce. [Bul. Pap. Chem. V. 26, No. 6]

Properties

B. J. Rendle. Tension wood. A natural defect of hardwoods. *Wood*, Vol. 20 No. 9, September 1955, pp. 348–51, 10 illus.

Tension wood is a natural defect that may be formed in a wide range of hardwood trees where it occurs typically on the upper or tension side of leaning or crooked stems. It is liable to cause distortion, splitting and collapse in seasoning, and difficulties in machining and finishing.

In the log any indication of irregular growth may be a sign of tension wood; thus it is fairly common in rough, misshapen logs of home-grown elm, oak, beech, poplar etc. It is generally associated with eccentric growth. In some timbers the zones of tension wood have a lustrous appearance; in others they are darker or denser than the normal wood. Sometimes its presence is revealed by the unusually rough end-surface.

In extreme cases machining operations are slowed down and the quality of the machined surface is inferior. It is essential that the tools used should have keen cutting edges, and it is advisable to use the normal cutting angle of 30°.

Tension wood has abnormally high longitudinal shrinkage in drying. This may cause distortion, splitting or even collapse during seasoning, it may cause distortion when the timber is re-sawn and it may cause buckling of veneers. [F. D. C. Tech. Bul. V. 5, No. 29]

Glues and Gluing

Infra-red heat speeds bonding plastics laminates to frames. *Canadian Woodworker*, Vol. 55, No. 11, November 1955.

To speed up the application of plastic sheeting to core panels or table tops, infra-red heating is used.

When the sheeting is to be applied to core panels, the panel is spread with glue and after infra-red heating for 45 seconds the plastic sheeting is pressed on to it by pressure rollers. Panels of 15 in. × 9 in. to 40 in. × 18 in. can be glued at the rate of one per minute whereas only 80 per day were produced by hand working.

The infra-red bank consists of seven rows of 10 375-watt 115-volt lamps connected five in series on a 575-volt three-phase circuit, and are mounted 8 in. from the work giving heat of approximately 200° F. [F. D. C. Tech. Bul. V. 6, No. 32]

Finishing

J. Starr. New electrostatic processing methods. *Organic Finishing*, Vol. 17, No. 3, March 1956.

This new electrostatic process involves the suspension of fine thermoplastic dust in air so that it can be charged for uniform deposition, the dry coating particles being retained by the surfaces to be readily fused with heat. This method of fusing eliminates the need for coating solvents and, as high temperatures are not needed, a greater variety of thermo-plastic resins with pigments and fillers included can be applied without oxidation.

At present the method appears to be most suitable for the finishing of fabrics, metals, leathers and veneers. [F. D. C. Tech. Bul. V. 6, No. 32]

Chemical Utilization

Farber, Eduard. Industrial applications of wood chemistry. Ind. Eng. Chem. 48, No. 3: 7–10A, 12A (March, 1956).

Wood-chemistry studies on the identification of substances present in wood and on the behavior of wood toward other chemicals are of great importance in present and future steps toward increased and better utilization of wood. Some of the main areas where more basic knowledge is required, unsolved chemical problems experienced in wood-working mills, and the need for more study of wood distillation and resins from wood wastes are pointed out. Progress in industrial applications utilizing the reactions of wood components are discussed and advances in the study of lignin cited. A list is presented outlining specific projects requiring study and wood products and processes awaiting further utilization. [Bul. Pap. Chem. V. 26, No. 8]

The preparation of abstracts from world literature in many languages is so highly specialized and costly that the Forest Products Research Society has no abstracting service of its own. For the abstracts in this issue of the JOURNAL the Society is indebted to the respective abstract journals indicated, from which they have been selected with the kind permission of the editors. Readers wishing information in addition to that given in these abstracts should consult the original articles referred to. Copies or additional information can not be supplied by FPRS or the abstract journal. The journals from which abstracts are published in this issue are as follows:

BULLETIN OF THE INSTITUTE OF PAPER CHEMISTRY, published monthly at Appleton, Wisconsin by the Institute of Paper Chemistry, subscription price $25 per year. This Bulletin publishes over 3,600 abstracts per year on subjects of interest to manufacturers of pulp, paper, fiberboard and allied products.

CHEMICAL ABSTRACTS, published semimonthly by the American Chemical Society, Executive Office—1155 Sixteenth Street, NW, Washington 6, D. C., subscription price $60 per year plus postage. This abstract journal publishes many thousands of abstracts annually with broad coverage of world literature in the entire field of chemistry and allied subjects.

TECHNICAL BULLETIN OF THE FURNITURE DEVELOPMENT COUNCIL is published bimonthly by the Council at 11 Adelphi Terrace, London W. C. 2, England. The Technical Bulletin publishes hundreds of abstracts and reviews from world literature annually, relating to the various phases of the furniture manufacturing industry. Subscription price is $5 per year.

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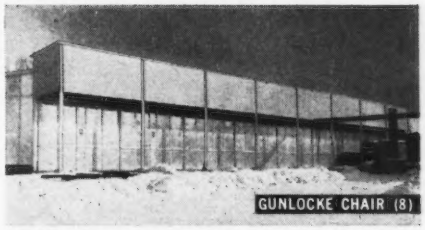
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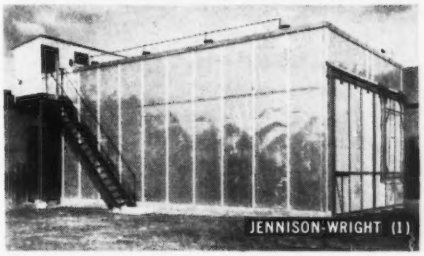
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Wood Drying Committee Newsletter

Uncover Seasoning Losses and Cover Seasoning Yards[1]

RARELY DO YOU FIND lumber seasoning yards without some signs of seasoning degrade or loss. The loss is accepted as normal procedure and in many instances little effort is made to remedy the situation. Lumber prices are reaching the point where a loss of a relatively small volume represents a sizeable value.

This study was suggested in an effort to throw some light on the effect weathering and exposure have upon degrade or loss of usable material.

Procedure: To determine the loss and yield of hardwood lumber, attributable to unsatisfactorily covered or uncovered air-seasoning stacks, a period of 3 to 6 months air drying was considered somewhere near or slightly longer than the average time between sawing and kiln drying. Ten stacks of lumber 10 feet high, 8 feet wide, and 12 feet long were used as a sample for each species. Most of the lumber in each stack was 12 feet long. The top four layers of yellow-poplar lumber and the top five layers of black and tupelo gum were used in the study.

A measurement and tally of yield of usable lumber involves many factors. In developing the procedure for collection of factual information, the best solution seemed to be a yield measurement after ripping and cutting the stock into actual usable lengths in a furniture plant. This yield would have no direct relationship to lumber grade but would correspond with regular use, operations, and quality practices in manufacturing. Solid furniture was manufactured, consequently nonacceptable material would include seasoning checks. Warpage was determined when the lumber obviously could not be ripped into flat pieces, which would finish smooth on both surfaces. Thin lumber was placed in the same category since it was not fully surfaced. All lumber was graded as No. 1 Common according to National Hardwood Lumber Association grades.

To compare yield of top layers, lumber from around the center of the same 10 stacks or similar stacks was used as the control, accumulated as stacks were cut, and processed as a group.

Results: A summary of the percentage loss and the per cent yield of yellow–poplar lumber and gum lumber is shown in Table 1.

In collecting these data, the normal reduction in usable lumber volume due to saw kerf, edgings, knots, and other rough-end machining is deducted even though the lumber is not usable due to warpage and checking. The percentage loss due to warpage and checks on ends and surfaces is therefore a loss in yield which can be reduced. The control loss and yield data, taken from the lower portion of the kiln truck, show a comparatively high per cent yield primarily due to the plant's ability to utilize small pieces as well as material not considered worth salvaging in many plants. A lower control yield value would increase the percentage loss in yield in unprotected yard storage. Warpage accounted for the greatest percentage loss in yield in both yellow-poplar and gum stacks. Gum warps badly when not restrained and actually 100 per cent of some boards were unusable due to warpage.

Loss Computation: Using the yellow–poplar loss in yield for the top layers of uncovered air seasoning stacks (Table 1), the loss in yield per stack or per kiln truck can be computed. A kiln truck 8 feet wide by 10 feet high containing 60 courses of 12-foot lumber at 90 board feet per course will hold 5,400 board feet. The top four layers will have 360 board feet. If 68 per cent of the top layers of yellow–poplar lumber is usable, the actual loss is 115 board feet per stack or kiln truck. The percentage loss per kiln truck is 115 ÷ 5,400 or 2.1 per cent.

A loss of 2.1 per cent sounds rather insignificant. If a plant uses 20 M feet per day for 250 working days, the total volume would then be 5 million board feet. Computed annually, the loss would be 5000 M x 2.1 or 105,000 board feet. At the current price of No. 1 Common yellow–poplar lumber, plus kiln drying costs, plus rough end costs, etc., or the value of usable stock prior to gluing, estimated at 200 per M board feet, the actual loss is $21,000.

Since many plants are using gum, and other species comparable to gum in seasoning degrade, the loss of this material (Table 1) is of greater interest. A plant using such material in an uncovered seasoning yard has a loss of 46 per cent of the top five layers, or 207 board feet per kiln truck, and 3.8 per cent of the kiln truck load. A company using 15 M bd. ft. per day or 3.75 million feet annually would have a loss of: 3.8 x 3,750 x $20 = $28,500.

Insignificant as a reduction of 1 to 4 per cent of usable material per stack may be, this loss on an annual basis is rather phenomenal.

Carter points out that "entire yards have been covered by a simple pole type, flat or pitched-roof shed." These "pole-type sheds range in cost from 50 to 95 cents per square foot." He further states that "all of the concerns using sheds to cover their yards agree that within two or three years the building would pay for itself by a savings in raw material costs."

[1] Abstract of paper presented by Prof. Roy M. Carter, N. C. State College, Raleigh, N. C., at FPRS Tenth National Meeting, June 4-7, 1956, in Asheville, N. C.

Table 1.—LOSS AND YIELD OF NO. 1 COMMON YELLOW-POPLAR AND GUM LUMBER IN AIR SEASONING STACKS UNCOVERED FOR 3 TO 6 MONTHS

	Percentage loss due to								Yield			
	Warpage and thins		End and surface checks		Knots, etc.		Kerf and edgings		Per cent per M		Per cent of control yield	
Position	Poplar	Gum	Poplar	Gum	Poplar	Gum	Poplar	Gum	Poplar	Gum	Poplar	Gum
Control	3	5	5	4	15	12	12	12	65	67	100	100
Top layer	37	46	16	25	15	12	12	12	20	5	31	7
2nd Course	19	42	10	14	15	12	12	12	44	20	68	30
3rd Course	10	26	8	10	15	12	12	12	55	42	84	62
4th Course	6	16	6	7	15	12	12	12	61	53	95	79
5th Course		9		5		12				62		92
Average	18	28	10	12	15	12	12	12	45	36	68	54

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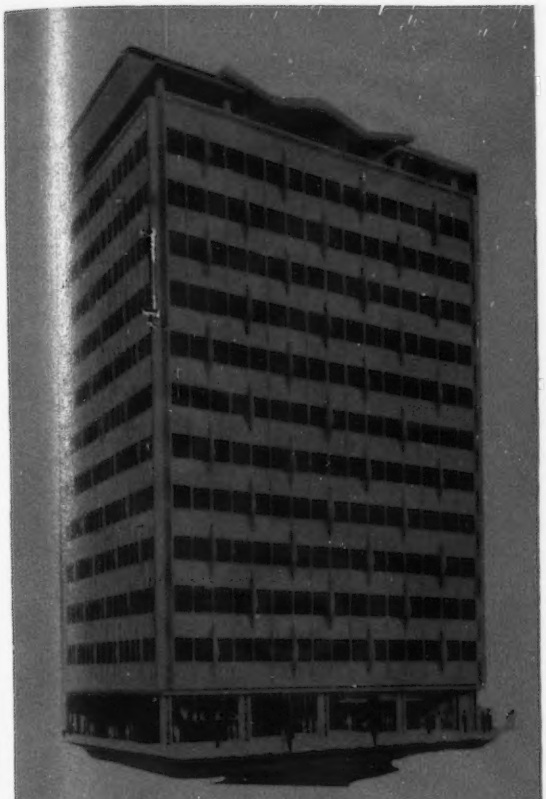

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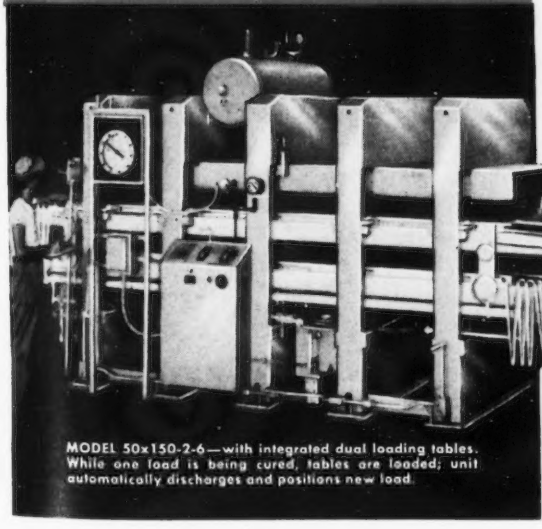

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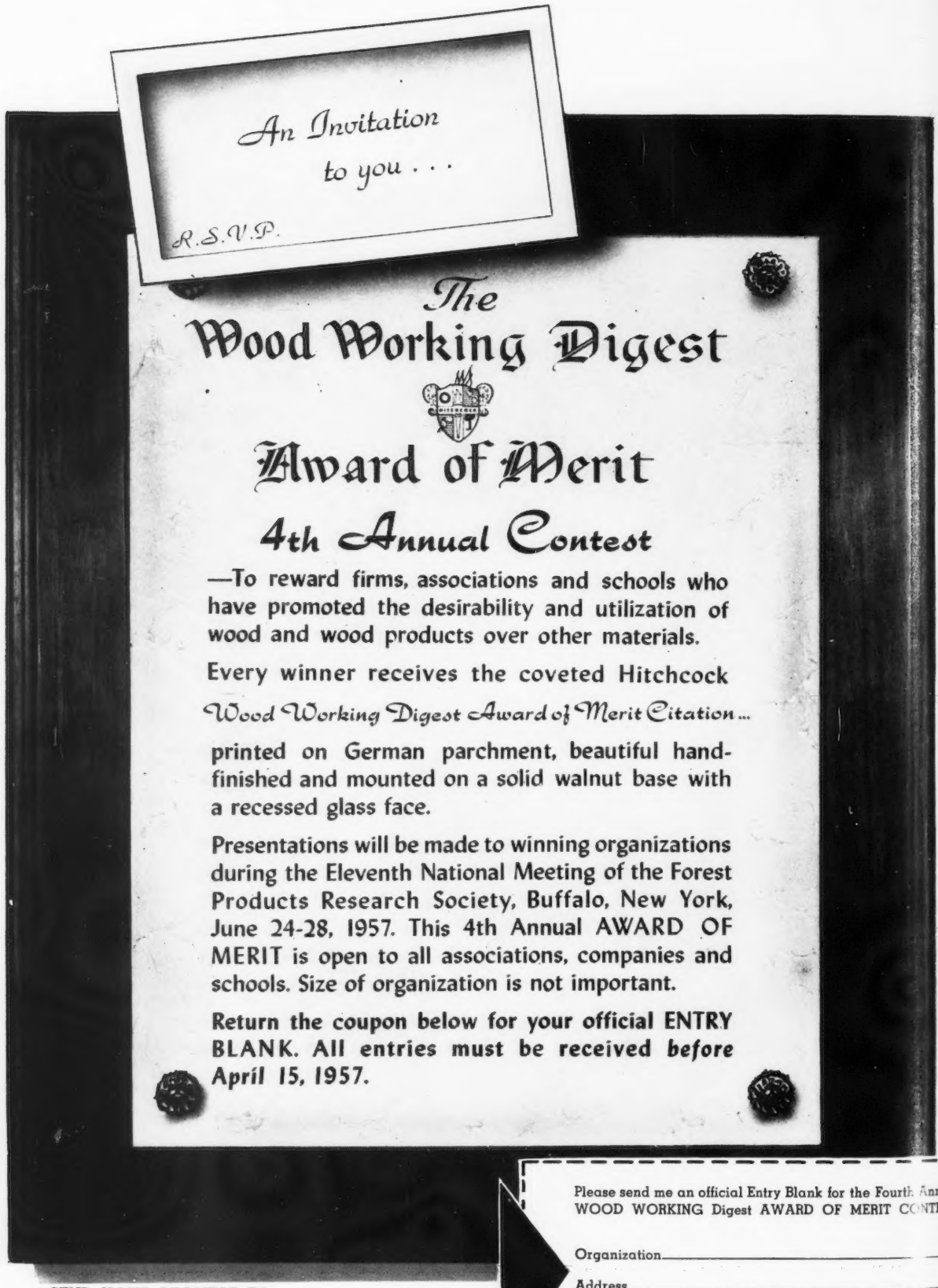
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